CLASS BOOK

OF

PHYSICAL GEOGRAPHY

BY

WILLIAM HUGHES, F.R.G.S.

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A CLASS-BOOK

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PHYSICAL GEOGRAPHY.

BY

WILLIAM HUGHES, F.R.G.S.,

AUTHOR OF A "CLASS-BOOK OF MODERN GEOGRAPHY,"
ETC. ETC. ETC.

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PREFACE.

THE growing attention bestowed in our schools upon the study of Physical Geography has seemed to the writer to justify the preparation of the following pages, which claim no higher merit than that of exhibiting, in clear and methodical arrangement, the principal facts respecting the natural features, productions, and phenomena of the Earth.

Those familiar with the geographical literature of recent years will at once recognise the extent of the author's obligations, in the earlier portion of the volume, to the well-known work of Arnold Guyot—"The Earth and Man"—the most philosophical treatise on the subject that has appeared in any language, and the only one that recognises the true place and bearing of geographical science, whether in its relation to other branches of study, or to the history of the human family. So high, indeed, is the estimate of M. Guyot's views entertained by the present writer, that he would not have added to the number of works already extant on the subject, had the arrangement of that author's pages been such as to fit them for general use as a class-book—which, from their very nature (consisting, as they

do, of a transcript of lectures) could not be the case. Reference is made in the course of the following pages to other authorities used in their preparation.

It may be desirable to mention that an Atlas of Physical Geography, for use in Schools, and designed as a companion to the present work, is in course of preparation by the publishers.

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PA

PHYSICAL GEOGRAPHY.

I.

THE EARTH AS A MEMBER OF THE SOLAR SYSTEM.

PHYSICAL GEOGRAPHY is the geography of the natural world: in other words, it is a description of the earth in respect of its natural features, productions, and general condition as the allotted abode of man. Such a description involves an account of the lands and seas which occupy the surface of the globe; of the varieties of climate which distinguish its different regions; the various movements and other phenomena which belong either to the ocean or to the atmosphere; the numerous varieties of life of which the earth is the seat; and, finally, the bearings of all these things upon the different nations of mankind, alike in their industrial, social, and political relations.

A moment's reflection serves to show that many of the topics embraced within this definition of Physical Geography are capable of being treated as distinct branches of study; and they require to be so treated, if it is intended to pursue them into their full detail. Geology, or the study of the rocks of which the earth's crust is composed; Meteorology, or the science which seeks to expound the laws which regulate the atmosphere; and the different branches of Natural History, or the description of the various forms of vegetable and animal life, with many subjects of less extended importance, are all more or less closely connected with an inquiry into the natural condition of the globe. But it is not necessary, for the purposes of Physical Geography, to enter upon the detailed pursuit of these subjects. A general view of their bearings and mutual relationship, in connexion with the physical aspect of the globe, is, for the most part, all that is required by the geographer. Some of the more important phenomena of the ocean and the atmosphere, as the currents and trade-winds, together with the laws that regulate climate,

demand, indeed, to be studied in detail. But the general aim of Physical Geography is to give a clear account of the great natural features of the Earth, and to show how, taken in conjunction with its climate and productions, they influence the condition of Man. All the branches of natural science are intimately connected with one another. It is impossible to study any one of them, without finding abundant traces of its relationship to cognate subjects of investigation. Their bearing upon the condition and prospects of civilised man, their connexion with past stages of progress in the history of the human race, impart to such inquiries the highest kind of interest, and invest them with an added charm beyond that which is always associated with the acquisition of knowledge. Such connexion, in the case of Physical Geography, is direct and obvious, as we shall have abundant occasion to point out in the following pages.

The first requisite to a due acquaintance with the physical condition of the earth, is the knowledge of its shape, magnitude, and motions, as a member of the Solar System.

1. The Earth constitutes one of a number of bodies which revolve in elliptical orbits round the Sun. These bodies are called planets. The Earth is one of the planets, and is the third in order of distance from the Sun, the two intermediate members of the system being the planets Mercury and Venus. Beyond the orbit of the Earth, that is, at greater distances from the Sun, are, in succession, the planets Mars, Jupiter, Saturn, Uranus, and Neptune, besides a great number of much smaller planetary bodies, (distinguished as asteroids,) which intervene between the orbits of Mars and Jupiter.

Of the planets above named, all but the two last, Uranus and Neptune, have been known and observed from the earliest period of antiquity. They are visible as shining points or stars in the heavens, and are readily distinguishable (when watched during any lengthened period, or even for a few evenings in succession) by their movement amongst the other stars. The vastly greater number of the stars which stud the sky, though they move, in common with the whole heavens, from east to west, yet always preserve *the same relative position to one another*. Hence it is that the constellations, or groups of stars—the well-known Great Bear, for example—maintain through all ages, and under all circumstances, the same figures. The planets, on the other hand,

have a movement amongst the fixed stars, and make the circuit of the heavens.

Uranus and Neptune, the two most distant known planets, have only been discovered within modern times, by the aid of the telescope. The former was first seen by Herschel, in 1781; the latter, at once, by Adams, an English astronomer, and Leverrier, a French observer, in 1846. The asteroids,* or smaller planetary bodies, have all been discovered within a recent period. As many as fifty-eight are now known, and the number may probably be increased. All of them are telescopic bodies, invisible to the naked eye.†

Some of the planets are attended by secondary planets, or satellites, which move in orbits round their primaries. Thus, the Earth is attended by the Moon, a body which is intimately connected with some problems of Physical Geography, by the influence which (as we shall see in a future page) it exerts over the waters of the ocean. In like manner, the planet Jupiter is attended by four satellites, or moons; Saturn by eight, and Uranus by six moons.

The planets and their attendant satellites, the asteroids, and the bodies known as comets, (which move in highly eccentric orbits round the sun, and most of which only become visible at lengthened intervals of time,) together with the Sun, round which luminary all their movements are performed, constitute the SOLAR SYSTEM.

The planets and their satellites, with the asteroids, are solid or opaque bodies, and receive their light from the SUN.

2. The Earth is a globe or sphere in shape, as likewise are all the other planetary bodies. It is not, however, a perfect sphere—being slightly flattened at the poles. Hence the popular comparison of its shape to that of an orange. But the deviation of the Earth from the figure of a perfect sphere is much less than the degree in which an orange differs from the same figure. The Earth's equatorial diameter measures 7926 miles, while its polar diameter is equal to 7899 miles, so that there is only a difference of 27 miles between the two.

* Greek, *aster*, a star—asteroid being used as a diminutive.

† The discovery, in 1859, by a French observer, of a telescopic planet between the orbit of Mercury and the Sun, has been announced. The name of Vulcan has been conferred upon this additional member of the solar system. Further proof of the existence of this planet is to be desired, and the attention of astronomers is actively directed to the subject. Several circumstances—chief amongst them the observed perturbations in the motion of Mercury—render it probable that not one only, but several such bodies, may ultimately be found within the region indicated.

This difference (represented by a fraction of $\frac{1}{304}$) is quite inappreciable upon any artificial representation of the Earth, and for all practical purposes of geography the shape of the planet which we inhabit may be regarded as that of a perfect sphere. The circumference of the Earth at the equator is equal to 24,899 English miles.

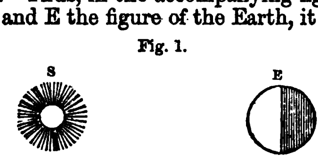
Using round numbers, and for the sake of facilitating the retention of the figures in the memory, we may say that the Earth's circumference is about 25,000 miles, and its diameter about 8000 miles; or, in more popular language, the Earth is said to measure 25,000 miles round, and 8000 miles through. The distance from any point on the surface of the Earth to its centre is therefore about 4000 miles.

3. The Earth, in common with the other planets, has two distinct kinds of motion—one, a movement on its own axis, which is accomplished within twenty-four hours; the other, a revolution round the Sun, which it takes a year to perform. The former is hence called its *diurnal*, the latter its *annual*, motion. It is of the highest importance that these movements should be thoroughly understood, since many of the most influential truths of Physical Geography are intimately connected with them.

(*a*.) The Earth's diurnal motion consists in a rotation of the globe round its own axis, in an eastwardly direction—that is, *from west to east*. In virtue of this motion, every object upon the surface of the globe is continually being carried round to the eastward, making a complete circuit once within twenty-four hours.

The Earth's rotation on its axis is the cause of day and night. The Earth is an opaque body, and receives its light from the Sun. Only one-half of it can be in receipt of the sun's light at any given moment—the half, that is, which is then turned towards the sun. The opposite half of the globe is in darkness. Thus, in the accompanying figure, if S represent the Sun, and E the figure of the Earth, it is obvious that

Fig. 1.



only that half of the circle marked as E can be receiving light at any given moment of time. The half which is on the op-

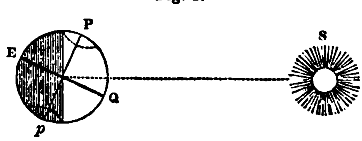
posite side to the sun must be in darkness. But as the Earth makes a complete revolution on its axis within twenty-four hours, every part of its surface passes in succession into the enlightened half of the circle, and afterwards passes into the dark half. Day and night, or light and darkness, thus succeed one another within every twenty-four hours.

(*b.*) The Earth's annual motion consists in an elliptical path, or orbit, which it describes round the Sun—the source of light and heat to all the bodies of the Solar System. This annual motion occasions the seasons—spring, summer, autumn, and winter—which succeed one another according as the Earth is in different parts of its orbit.

The cause of the differences of heat and cold, of shorter or longer days and nights, is found in the fact, that the axis of the Earth is not perpendicular to the plane of its annual motion, but is inclined to that plane at an angle of 66½°, (or, more strictly, 66° 32′.) Hence the line of the ecliptic,* or apparent path of the sun in the heavens, makes with the line of the equator an angle of 23½°. The amount of this inclination is unvarying—the Earth's axis, in whatever part of its orbit it may be, always preserving the same direction in space. The mid-day sun is therefore vertical, in succession, to different points on the globe, these points ranging as far as 23½° upon either side of the equator, in the way that is explained in the following figures.

In figure 2, the Earth's axis is represented by the line P *p*, the letters P and *p* marking the places of the poles. The

Fig. 2.

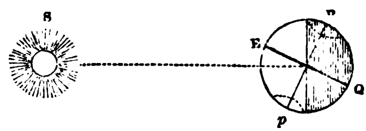


line E Q marks the equator. S is the Sun. The shaded portion of the Earth's figure (or that which is turned away from the sun) is, of course, in darkness, while the other half is receiving light. Now, in this position of the Earth relatively to the Sun, it is obvious that the line which divides the enlightened from the dark half of the globe does not coincide in position with the Earth's axis. One of the poles, and a

* Greek, *ekleipsis*, an eclipse, because eclipses only happen when the moon's place in the heavens is either on or near this line.

certain space (23½°) round it, fall entirely within the enlightened half, while the other pole, and a similar surrounding space (23½°), are wholly within the dark half of the globe. In figure 3, while the same direction of the Earth's axis is preserved, precisely the reverse of the above is the case. The Sun is here upon the opposite side of the Earth. That one of the Earth's poles, P, which in the previous instance fell

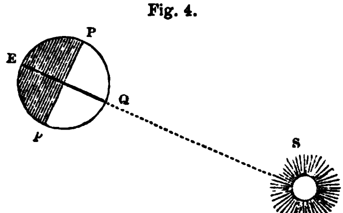
Fig. 3.



within the enlightened half of the circle, here falls within the shaded portion of the globe, while the opposite pole is within the enlightened half. In other words, supposing P to represent the north, and *p* the south pole, in the former case the north pole, and a space of 23½° round it, are in light, and the south pole in darkness; while in the latter, the south pole and an encircling space of 23½° are in light, and the north pole in darkness. In either of these cases, a line drawn from the Sun directly to the Earth's surface does not coincide with the equator, but falls either above or below that line. In the one case it is to the north, in the other to the south of the equator. The extreme extent of its distance from the equator is the same as that of the circles of light or darkness around either pole, or 23½°. This distance upon either side of the equator marks the place of the tropics.*

Figures 4 and 5 show the relative positions of the Earth

Fig. 4.

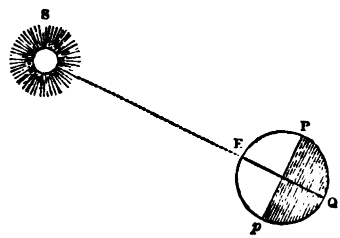


and Sun under opposite circumstances, or when the line of

* Greek, *trepo*, I turn. Because the sun, when it has reached this, its extreme distance from the equator, turns again toward that line.

the Earth's axis coincides with the line which divides the enlightened and dark halves of the globe. The direction of the Earth's axis in space (indicated by the line P p) is still

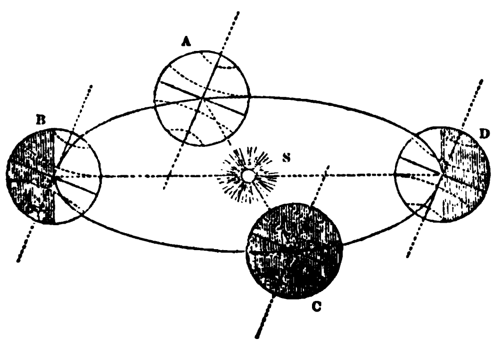
Fig. 5.



preserved, but the Sun is here, in either case, vertically over the line of the equator, and a line joining the poles therefore marks the division between the light and the dark halves of the Earth's surface.

In the course of the Earth's annual motion round the Sun, each of the above four positions is realised, as is shown in the diagram, figure 6. The positions of the Earth, which are here successively marked as A, B, C, D, coincide with the

Fig. 6.



several positions of the Earth and Sun, which are shown in the separate figures 2, 3, 4, 5, and they mark the respective positions of the Earth and Sun at the times of the summer and winter solstices, and the spring and autumnal equinoxes.

The ellipse which is drawn round the Sun, and upon which the four figures of the Earth are marked, represents the plane of the Earth's orbit—that is, the path in which its annual motion round the Sun is accomplished. In every part of this circuit the direction of the Earth's axis in space is the same —making always an angle of 66½° with the plane of its orbit —so that the lines of the ecliptic and the equator are inclined to one another at an angle of 23½°. The positions of the Earth marked A and C coincide with those shown in figures 4 and 5. The north and south poles here fall exactly on the limits of the enlightened and dark halves of the globe, and the sun is vertically over the equator. These positions mark the spring and summer equinoxes*—that is, the 21st March and the 21st September.

The positions marked (in figure 6) as B and D correspond to those shown in figures 2 and 3. At B, the north pole is wholly within the enlightened half of the circle, and the Sun is vertical over a point of the Earth which is 23½° on the north side of the equator: this is the season of the summer solstice† —that is, the summer of the northern hemisphere, when the Sun attains, on the 21st June, his extreme northern limit, or declination.

At D, the south pole is illumined, while the regions round the northern pole are involved in darkness, and the vertical place of the Sun is 23½° to the *south* of the equator, or in the winter solstice, which it reaches on the 21st December.

As the Earth passes through the different points of its orbit, from A to B, C, and D, and thence again to A, the different seasons of spring, summer, autumn, and winter are experienced in succession by its inhabitants, and the respective length of the days and nights in either hemisphere becomes increased, or the reverse, according to its position. The position B, which marks the midsummer of the northern hemisphere, is the midwinter of the southern half of the globe. The position D, on the other hand, which is the midwinter of the northern side of the globe, is the midsummer of that half which is to the south of the equator. So with the positions A and C: the former is the spring or vernal equinox, the latter

* Latin, *æqua nox*. Because when the sun is in either of these positions there is equal day and night (each of twelve hours duration) throughout the globe.

† Latin, *solstitium*, from *sol*, the sun; and *sto*, I stand. Because the sun, when it has reached this point in the heavens, seems to stand for a while ere returning again towards the equator.

the autumnal equinox, to the northern half of the globe. To the people of the southern hemisphere, C marks the position of the vernal and A of the autumnal equinox.

The varying lengths of the days and nights, in every part of the globe, depend upon the place of the Earth in its orbit. Under the line of the equator alone, day and night are each, throughout the year, of exactly twelve hours' duration. In the position marked A, (that of the vernal equinox,) the days and nights are of equal length throughout the globe, each being of exactly twelve hours' duration. As the Earth advances from A to B, the length of the days is continually increasing to all places within the northern hemisphere, and the length of the nights is undergoing correspondent decrease. In the position B, (midsummer of the northern half of the globe,) the difference attains its greatest extreme. During the Earth's progress from B to C, the periods of light and darkness are gradually returning to equality. The days are gradually becoming shorter, and the nights longer, at all places within the northern hemisphere, while the reverse is taking place upon the southern side of the equator. At C, (the autumnal equinox,) there is again equal day and night, each of exactly twelve hours' duration. During the Earth's progress from C to D, the days are gradually becoming longer, and the nights shorter, within the *southern* hemisphere, and the position D indicates the midsummer of southern latitudes. The passage from D to A, again, marks an increasing length of day in the northern, and a corresponding decrease in the southern half of the globe. Thus long days and short nights characterise one half of the year, in either hemisphere, and are succeeded by an opposite period of short days and lengthened hours of darkness.

The regions that are within 23½° of either pole, it will be observed, are alternately in perfect light or in entire darkness, according as the Earth is in the position of the summer or winter solstice, (A and D.) The north pole is receiving the sun's light during the whole period of the Earth's passage from A to B and from B to C—that is, for six months of the year, during all which time the south pole is in darkness. During the remaining half of the Earth's orbit, (from C to D, and from D to A,) the south pole, on the other hand, is constantly receiving light, and the northern pole is in darkness. Hence, at the poles there is an alternate day and night of six months' duration. And at all places that lie

between the poles and a distance of 23½° (marked, in either hemisphere, by the lines of the Arctic and Antarctic* circles) there are alternate periods of light and darkness which exceed twenty-four hours in length. The effect of these conditions upon the climate of regions so situated will be seen in a future chapter.

* Greek, *arktos*, the bear, a constellation towards the north pole, whence the term is used to signify north; antarctic, opposite to the north.

II.

GENERAL FEATURES OF THE EARTH'S SURFACE.

THE superficies of the globe is equal, in round numbers, to 197 millions of English square miles. Nearly three-fourths of this area, or upwards of 145 millions of square miles, are covered by the waters of the ocean, with its numerous seas and other subdivisions. The visible Land occupies little more than a fourth part of the Earth's surface. But it must be remembered that the ocean is in reality only a superficial interruption to the continuity of the land, which is continued beneath the waters, and rises (at intervals of greater or less frequency) above their level.

The distribution of Land and Water over the Earth's surface is exceedingly irregular, as an inspection of the Map of the World—or, better still, a careful examination of the artificial globe—shows. Looking at the equator as a line of division, it is at once obvious that the larger portion of the Land is within the northern hemisphere. The inequality in this regard is apparent in the Old and the New Worlds alike. The whole of the European, Asiatic, and North American continents, the larger part of Africa, and a small portion of South America, are to the northward of the equator. In all, the lands within the northern hemisphere amount to not less than three-fourths of the entire solid portion of the Earth's crust. This great preponderance of land upon the northern side of the equator is attended by many important results upon the temperature and other conditions of climate which distinguish particular regions of the Earth.

The arrangement of Land and Water is equally irregular, if regarded in the direction of east and west, as in that of north and south. The line of a great circle drawn round the globe at 20° west of Greenwich, (that is, the meridian of 20° west,) is commonly regarded as dividing the Earth into an Eastern and a Western hemisphere. This division is of course arbitrary, but it is highly useful, as serving to bring the three

continents of the Old World—Europe, Asia, and Africa—into one half of the Map of the World, while the continents of North and South America fall within the other half. It is at once apparent, on this arrangement, that the eastern hemisphere includes a vastly greater portion of land than the western. Not only do Europe, Asia, and Africa, fall within its limits, but it also includes Australia—the only one of the continents that is wholly to the south of the equator. The proportion of Land which falls within the eastern hemisphere is equal to nearly five-sevenths of its whole extent.

An arrangement still more strikingly indicative of the irregular distribution of Land and Water is obtained by regarding the British Islands as occupying a central position amidst the lands spread over one-half of the Earth's surface. If the line of a great circle everywhere 90° distant from London be used as dividing the globe into two hemispheres, (of one of which London would form the central point, and of the other, a spot in the South Pacific Ocean which coincides with the antipodes of London,) it is found that the continents of the Old and New World—with the exception of a small part of South America—alike fall within the limits of a single hemisphere. The lands that are included within the opposite hemisphere do not constitute more than one-eleventh part of the whole land-area of the globe.*

The considerations above adverted to establish three great truths in regard to the arrangement of Land and Water on the Earth's surface.

1. The Northern hemisphere contains a vastly greater portion of land than the Southern hemisphere, in the ratio of three to one.

2. The Eastern hemisphere includes a much larger portion of land than the Western half of the globe, the former being to the latter nearly in the ratio of five to two.

3. The division of the globe by the line of a great circle distant 90° from London exhibits a terrestrial and an oceanic hemisphere, the proportion of land within the former of which exceeds that in the latter in the ratio of ten to one.

The Northern hemisphere is hence more continental than

* This arrangement is readily shown on the artificial globe, by elevating the north pole 51½° above the horizon, and bringing London into the place of the zenith. No other spot can be selected which will bring so great a portion of the lands of the globe within the limits of a single hemisphere.

the Southern, and the Eastern more so than the Western half of the globe. The British Islands occupy the central place in a terrestrial, and their antipodes * in an oceanic, hemisphere.

It is of scarcely less importance than the above considerations, to observe that a very large proportion of the lands on the Earth's surface fall within temperate latitudes, and are hence free alike from the extremes of heat and cold which belong to regions situated in more immediate proximity either to the equator or the poles. The proportion of land to water is much greater in the north temperate zone than in any of the other zones. A glance at the map shows how vast a portion of the Old World is included between the tropic of Cancer and the line of the Arctic Circle. The lands that are embraced within this belt of the earth—stretching in the direction of east and west, between the waters of the Pacific and Atlantic Oceans, through more than a third of the circumference of the globe—are best suited for the development of man's highest powers. The same extent of land, situated either beneath the vertical sun of the torrid zone, or exposed to the ice of the polar latitudes, would have tended to produce very different results upon the destinies of the human race.

The external shape or contour of land and sea, is a feature deserving of careful consideration. The aspects of different regions are very various in this regard. According as the outline of a country is more or less varied, it has a greater proportionate extent of coast-line, or the reverse. Its facilities for commerce, and for the various kinds of social intercourse and improvement which are associated with commerce, are in great measure dependent upon this. The Mediterranean Sea has conduced in no small measure to the civilisation of mankind. It was by its means that the nations of the west first assumed their rank in the onward march of civilisation—a rank which the nations of the east have never been able to dispute with them. It is hardly too much to say, with Heeren, that had an extensive heath occupied the place of this inland sea, we should yet, like the nomades of Central Asia, have been wandering Tartars and Mongolians.

No other portion of the globe can compare with Europe in

* Greek, *anti*, against or opposite to; *pous*, a foot.

the rich diversity of coast-line which marks its sout western shores. The numerous peninsulas, advanci lands, with deep and sinuous recesses between, and t adjacent islands, with their varied aspects, which b the circuit of the Mediterranean coasts, have no para where. The tropical seas of the Eastern and Westeri exhibit insular regions of greater magnitude, but t where show the same combination of peninsula and coi of island and land-enclosed gulf, which forms the i characteristic of Southern Europe, nor is their siti beneath the vertical sun of the torrid zone, so favour man. A similar diversity belongs to the shores of W and North-western Europe. The Baltic and its gulfs, th that surround the British Islands, the gulfs which inden shores of Holland and France, exemplify the characterist Europe in this regard. The Mediterranean shores alon hibit a circuit of more than thirteen thousand miles— without reckoning the coast-line of the numerous islands wl its waters enclose. Two-thirds of this extended range of c belong to its European side. The shores of the British Isla display a circuit of more than six thousand five hundred mi —a development of coast-line which, compared to exte of surface, is truly astonishing, and which serves in no u important measure to illustrate the maritime greatness of t British nation.

Of all the continents, Europe has the most extensive de velopment of coast-line compared to its superficial extent Africa the least. Asia has a diversified contour, especially upon its southern and eastern shores, but its vast interior is far removed from maritime influence. The peninsulas of Asia bear a very much smaller proportion to the whole extent of its mainland than do those of Europe to the entire surface of the European continent. Africa exhibits a vast solid mass, unbroken by the surrounding seas.

Of the three continents of the Old World, Africa is the most simple in form; "it is," says Guyot, "a body without members, a tree without branches. Asia is a mighty trunk, the members of which, however, make only a fifth of its mass. In Europe, the members overrule the principal body—the branches cover the trunk; the peninsulas form almost a third of its entire surface. Africa is closed to the ocean; Asia opens only its margins; Europe surrenders entirely to it, and is the most accessible of all."

Comparing the external contour of each continent with its superficial extent, we find that Europe has, in proportion to the extent of its surface, nearly three times as much coast-line as Asia, about four times as much as Africa, more than twice as much as South America, and nearly twice as much as North America. The last-named continent makes nearest approach to the typical character of Europe in this regard, especially upon its eastern or Atlantic shores. In Australia, the continent of the southern hemisphere, though the whole mass exhibits solidity of shape, yet the surrounding oceans give it a development of coast-line which, though much inferior to that of Europe, is relatively considerable. The coast-line of Australia, comparatively to its superficial dimensions, is two and a half times greater than that of the African continent, and nearly equals the proportion which is exhibited by North America.

The relief, or comparative elevation, of the land is an inquiry of vast importance to Physical Geography. The direction and slope of the lower grounds, the courses of rivers, the climate and various conditions of life, are intimately connected with this, and in great measure depend upon it.

The great division of the earth's surface in this regard is into highlands and lowlands. The former embrace the mountain-chains which form, in many cases, the external barrier of plateaus or table-lands, as well as those extended regions of the globe to which the term "table-land" is generally applied. Many such regions reach a vast altitude above the average level of the earth's surface. The distinction between highland and lowland tracts is, in such cases, sufficiently obvious; but it should be remembered that the one often passes by insensible degrees into the other, so that the two features—widely contrasted in their types—yet blend in some measure together. It is often difficult to draw the line at which the valley terminates, and the slope of the hill-side begins; and the great lowland plains which stretch from the shores of the ocean towards the distant interior pass gradually into regions of elevation. It is thus with the high mountain-chains. The summits of the Alps or the Himalaya are only reached by the ascent through lower chains of hills, which rise by successive stages, at first above the plain at the foot of the mountain-region, and afterwards above succeeding terraces of inferior height.

1. One law which appears to govern the distribution of the highlands of the globe is this: they are found in more or less immediate proximity to the ocean, and present their steep acclivities towards its waters. The highlands and mountain-ranges of the Asiatic continent, though they stretch over large regions of the interior, are yet much nearer to the Indian and Pacific Oceans than to the shores of the Arctic Sea. The mountains of Europe press closely upon the Mediterranean shores, and the highlands of Africa are found in proximity to the coasts. In the New World, the same feature is still more strongly marked: in North and South America alike, the higher mountain chains belong to the shores of the Pacific, and are nowhere far removed from its waters.

2. A second law (and one which results from the above) is, that the land in either hemisphere—looked at in large masses—exhibits widely-different features in its two slopes. The one is a short and abrupt declivity, the other a long and gradual slope. The latter is suited to the formation of lengthened river-courses, the former involves shorter and more rapid streams, of torrent-like character.

In the Old and New Worlds alike, the shorter slope of the land is directed towards the Pacific and Indian Oceans, the longer slope toward the Atlantic and Arctic basins. In other words, in the Old World, the general slope of the land is from south to north; in the New World, from west to east. Hence results the fact that so many of the larger rivers of the globe discharge either into the Atlantic Ocean, or into the Arctic Sea, which forms a part of the Atlantic basin. In asserting this as a general rule, it is not meant to be implied that the shores of the Pacific and Indian Oceans are wanting either in lowland plains of considerable extent, or in lengthened river-courses. The great rivers of the Chinese plains, and the streams that water the fertile lowland of Northern India, would prove the fallacy of such a dogma. But still, looking at the continental land-masses as a whole, the truth of the proposition is obvious; and the following diagrams, which exhibit the comparative elevations in either hemisphere, by means of sections which follow, in the case of the Old World, the direction of north and south, and in the New World, that of east and west, offer a convincing proof of it.

OLD WORLD.

FIG. 7.

SECTION FROM THE MOUTH OF THE GANGES TO THE ARCTIC OCEAN. (S. to N.)

OLD WORLD.

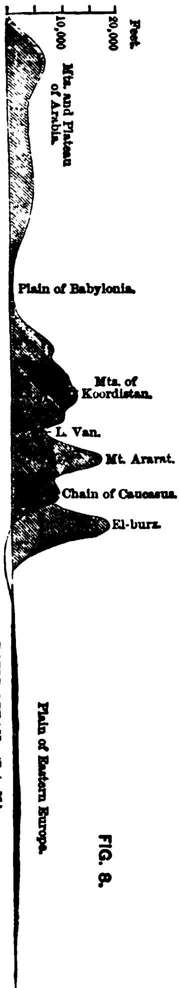


FIG. 8.

SECTION FROM THE SOUTH COAST OF ARABIA TO THE ARCTIC OCEAN. (S. to N.)

OLD WORLD.

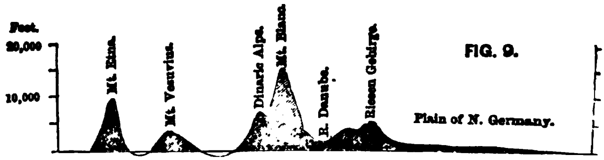


FIG. 9.

SECTION FROM THE MEDITERRANEAN TO THE BALTIC. (S. to N.)

NEW WORLD.

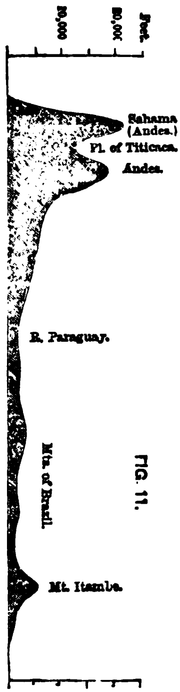


FIG. 11.

SECTION FROM THE PACIFIC TO THE ATLANTIC. (S. AMERICA—W. to E.)

NEW WORLD.

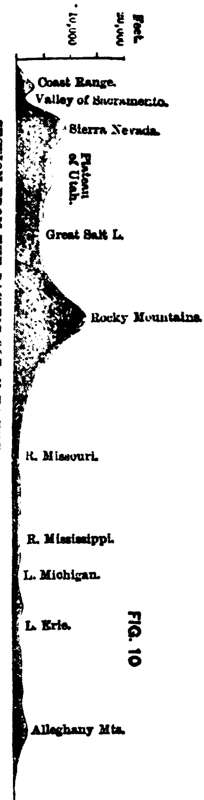


FIG. 10

SECTION FROM THE PACIFIC OCEAN TO THE ATLANTIC. (N. AMERICA—W. to E.)

These figures illustrate the truth, that the same law prevails with regard to plateaus and mountain-chains alike. The highest elevations on the surface of the globe belong to the Himalaya chain, situated within the Asiatic continent, and the plateau of Tibet—the loftiest among the elevated land-masses of the globe—forms a constituent portion of that mountain-region. In the New World, the Andes exhibit the loftiest summits that are found within the western hemisphere, and the Cordilleras or chains which constitute the mountain-region enclose between them the table-lands of Pasco and Titicaca, which rival the plateaus of central Asia in height.

It follows, from what has been said above, that the arrangement of the land-masses of the earth may be studied under three different aspects, viz., *position*, *contour*, and *relief*. These, though in some respects distinct, are yet in intimate connexion with one another, and their combined influences are of the highest importance to man. The positions established in regard to them may be thus summed up:—

1. There is more land in the Northern than in the Southern Hemisphere, and more in the Eastern than in the Western Hemisphere.
2. The most striking contrasts in the distribution of land and water result from a division of the globe marked by the line of a great circle distant 90° from London. More than nine-tenths of the land are thus shown to be within a hemisphere of which London is the central point.
3. The Atlantic coasts of either hemisphere exhibit a greater variety of contour than belongs to the shores of the other oceans.
4. Europe is characterised in a superior degree to either of the other divisions of the globe by diversity of contour, and consequent development of coast-line. Africa exhibits, beyond any other continent, the opposite type of solid and unbroken mass.
5. The land exhibits, in either continent, two great slopes —a long and a short slope. In the Old World, the longer slope is from south to north; in the New World, from west to east.
6. The highest elevations in the Old World are found

in the Himalaya Mountains (Asia); the highest in the New World belong to the great chain of the Andes, in South America.

The highest measured elevation on the surface of the globe is Mount Everest, one of the snow-covered summits of the Himalaya chain, on the northern border of India. This reaches 29,000 feet (or five and a half miles) in absolute height above the sea. The highest ascertained elevation in the New World—Aconcagua, in the Chilian Andes—falls short of this by about five thousand feet.

Such elevations as the above are stupendous in themselves, and as compared to the works of man they are surpassingly great. But the proportion which they bear to the general mass of the globe is insignificant in the extreme. A minute grain of sand placed upon the largest of our artificial globes more than represents the altitude and mass of Mount Everest, by comparison to the whole body of the earth. The highest elevations on the globe are equivalent to less than a seventh-hundredth part of the earth's radius.

III.

CONSTITUENT PORTIONS OF THE EARTH'S CRUST.

It is not enough to notice merely the distribution of land and water on the earth's surface. We require to know what are the component parts of the land, what laws regulate their general arrangement, and to what changes they are subject through natural agencies, if we would rightly comprehend the truths of physical geography. The study of the rocks* which compose the successive strata of the earth's crust, in reference to their respective ages and their various fossil contents, forms the proper subject of geology.† The general truths of this science blend with those of physical geography. A diligent examination of the natural phenomena of the globe under its present conditions affords to the geologist the best aid in the endeavour to explain the successive changes which it has undergone in former periods.

"The materials composing the earth's crust," (says an able writer on geology,) "are rocks of various kinds—as granite, roofing-slate, marble, sandstone, coal, chalk, clay, and sand—some hard and compact, others soft and incohering. These substances do not occur indiscriminately in every part of the world, nor, when found, do they always lie in the same positions. Granite, for example, may exist in one district of a country, roofing-slate in another, coal in a third, and chalk in a fourth. Some of these rocks occur in irregular mountain-masses, while others are spread out in regular layers or courses, termed *strata*, from the Latin word *stratum*, strewn or spread out."‡

The great division of the substances above referred to, as

* In a geological sense—that in which the term is here used—the word "rock" is held to embrace every description of substance which goes to compose the solid portion of the earth's surface, whether it be of hard and close texture, such as granite, soft and yielding, such as clay, or composed of loosely-aggregated particles, like sand or gravel.

† Greek, *ge*, the earth, and *logos*.

‡ Advanced Text-book of Geology. By S. Page. 1856.

composing the earth's exterior, is into two classes, which are designated by the terms *aqueous* and *igneous*. The latter* bear evidence of having been due to the agency of fire; the former,† to the fact of their deposit by water. The aqueous rocks uniformly exhibit a series of layers, or strata, evidently resulting from their formation under water; hence they are termed sedimentary or stratified formations. The igneous rocks, on the other hand, exhibit no stratified arrangement, but appear as masses of various form, in many cases bursting through and displacing the sedimentary deposits—"here appearing as walls, filling up rents and chasms, there rising up in huge conical hills, and in another region flowing irregularly over the surface in streams of lava."

Nearly every railway-cutting offers an example of rocks formed by sedimentary deposit, and the regular layers which the solid rock, thus exposed to view, exhibits, can scarcely fail to attract the notice of even the least observant among passing travellers. The exposed hill-sides, of frequent occurrence in hilly districts, and the walls of cliff which line so many parts of our sea-coast, afford like opportunities of observing the important fact of arrangement in layers, or strata. We see around us abundant examples—in every running brook which carries down particles of earth, and deposits them in the lower portions of its bed, and in every shower of rain which washes down the particles of sand or gravel, to become spread out at the foot of a rising ground, or the base of a cliff—of the kind of agency which must have formed, by deposit under water, the various sedimentary formations. The conclusion is irresistible, that such formations must have been formed in like manner, during long prior periods of time, and that what is now dry must formerly have been under water. This conclusion is strengthened by the fact that within the rock-strata are found various *fossils*‡—the petrified remains of former life, vegetable or animal. The land and the sea have, in fact, changed places. The most elevated portions of what is now the dry land of the globe were at a former period covered by the waters of the ocean, and the different forms of the land—its mountain-chains, valleys, ravines, and various altitudes or depressions—have been in great measure determined by the transporting and hollowing-out powers of running water.

* Latin, *ignis*, fire. † Latin, *aqua*, water. ‡ Latin, *fossus*, dug out.

It seldom happens that the sedimentary strata which compose so large a portion of the earth's crust exhibit a perfectly horizontal arrangement through any lengthened distance. More frequently, they have been displaced by some agency subsequent to their original deposit, and have been upheaved in particular portions. The strata, as thus exhibited to view, are inclined at various angles to the horizon. Sometimes the successive layers of deposit are bent and distorted, giving evidence of the force of pressure exerted upon them. In some cases, the sedimentary strata are broken through by masses of igneous rock.

One prime truth established by the researches of the geologist is the fact that a certain order of succession is always maintained between particular strata. That is, that certain formations — clays, limestones, or sandstones — are always found to underlie one another, in regular series. Some of the formations may be absent from particular localities, and may be altogether unrepresented over extensive regions, but the existent strata, of whatever they may consist, maintain an invariable order of succession. Chalk, for example, always occupies a higher place in the series than the limestones of the oolitic period, the latter are superior in position to certain descriptions of sandstone, and the last, again, to the carboniferous rocks.

Another great truth is this:—the sedimentary rocks contain, embedded within them, the fossil remains of former vegetable and animal life, and the remains that are proper to each series differ in many essential regards from those of any other series. Each class of rocks, in fact, indicates distinct conditions of life as having existed during the period of its deposit. Thus, the fossils found within the clay are different from those of the chalk, the latter, again, from those of the succeeding sandstones and limestones, and so on. The lower down in the series we go, the more do these evidences of former periods of life differ from the plants and animals which inhabit the globe in the present day.

The transition from the fossil contents of one series of rocks to those of another series is not abrupt. The forms of life which are characteristic of one epoch in the past history of the globe pass by gradual stages into those that are typical of a later period. Certain forms of life appear to die out, and others take their places. The change in this respect, from the fossil contents of the later to those of the earlier formations.

may be likened to that which occurs in the existent vegetation of a mountain-region. As the traveller ascends the lower slopes of the hill-side, he leaves behind him the characteristic foliage of the warmer plains—their luxuriant evergreens, rich fruits, and brilliant flowers. A hardier growth comes gradually under view: the laurels and myrtles are succeeded by groves of oak and holly, of beech or elm, while these in turn give place to forests of pine, which cover the mountain-side at higher elevations. As certain forms of vegetation become fewer in number, and at length disappear, others take their places, and although no precise line of division can be drawn between them, yet the contrast, when the typical aspect of the one region is compared with that of the other, is abundantly obvious. Between the vegetation found at the height of a thousand feet, and that of the mountain's base, there is a wide and manifest distinction, and the forms of life which prevail at an altitude of a thousand feet differ in like manner from those found at double that height.

It is thus with the evidence of former life-periods which the solid strata of the globe offer to the observer. The plants and animals that are embedded in the more recent formations—those which are highest in order of position among the sedimentary rocks—present types of life which scarcely differ in some regards from the like forms of life in the present day; while at the same time they offer many examples, both in the vegetable and the animal kingdoms of nature, of forms that have become extinct. Each succeeding series, in the order of descent, exhibits fossil contents which differ more and more widely from the forms that are characteristic of later periods, while each has a typical character of its own.

The classification of stratified rocks adopted by geologists in the present day exhibits the following order of sequence, beginning with those formations which lie uppermost, and proceeding downwards:—

1. Post-tertiary or recent accumulations.
2. Tertiary strata.
3. Cretaceous, or Chalk system.
4. Oolitic system.
5. Triassic, or Upper New Red sandstone.
6. Permian, or Lower New Red sandstone.
7. Carboniferous system.

8. Old Red sandstone, or Devonian system.
9. Silurian system.
10. Metamorphic system.

Of the series of rocks embraced within the above list, all but the last come under the designation of *fossiliferous*, since they contain the petrified or fossil remains of plants and animals. The rocks that belong to the last-named of the series, though they exhibit a stratified arrangement, yet contain no traces of former life, and are hence termed *non-fossiliferous*. Their designation of "metamorphic" implies the fact of their having undergone a change, probably by the combined agencies of heat and pressure, subsequent to the period of their deposition.

The terms bestowed on the above formations are indicative in some instances of the leading mineral characteristic of the rocks which they embrace; in others, of some fact connected with their geographical distribution. Thus, cretaceous (Latin, *creta*, chalk) implies the prevailing character of the rocks belonging to that series, as developed in the British Islands and elsewhere. The designation of oolitic (Greek, *oon*, an egg, *lithos*, a stone) was given from the fact of some of the limestones which it embraces being composed of small rounded and egg-shaped particles, like the roe of a fish. Triassic denotes the triple group (trias) in which the sandstones of the period which it indicates are commonly found in Germany, and the term Permian has been bestowed upon a lower series of sandstones from their extensive development within the government of Perm, in European Russia. The carboniferous (coal-yielding, Latin, *carbo*, coal, *fero*, I yield) strata are those which contain the extensive coal deposits of our own island, as well as the greater part of the coal of other regions. The term Devonian implies the extensive development of rocks which belong to the older and lower series of red sandstones within the county of Devon. The oldest members of the fossiliferous series—consisting, for the most part, of hardened sandstones and limestones, of slaty texture—have been distinguished as Silurian, from the name of the early inhabitants of South Wales, (the *Silures*,) within which region of our own island they are most extensively and typically developed.

The epithets of "post-tertiary" and "tertiary" bestowed upon the uppermost members of the series of sedimentary formations bear reference to a classification adopted by the

earlier geologists of all stratified rocks into tertiary, secondary, and primary, with reference to their supposed ages. The tertiary rocks were held to comprise all the formations which occupy a place above the chalk; while the strata from the chalk to the old red sandstone inclusively were included within the secondary series. The tertiary strata thus comprehend the various clays, marls, and limestones, which are superior in position to the chalk; while the post-tertiary system consists of the various accumulations which are of still more recent origin, and which are coeval with the existence of man.

The rocks of igneous origin exhibit no stratification, and have no determinate place amongst the various sedimentary deposits. Nor do they exhibit, as a general rule, any traces of organic being. The conditions of their origin—the agency of fire—account for the frequent position of their masses as breaking through and disrupting the sedimentary formations, forming dykes which break the continuity of the latter, or overlying the stratified deposits amongst which they are locally situate.

The entire series of igneous rocks is divided by geologists into three great classes—granitic, trappean, and volcanic. The first embraces granite in its various forms, with the different mineral masses, of crystalline texture, that are found associated with granite. The term *trap*, applied to the rocks that form the second division, is derived from a Swedish word, *trappa*, a stair, and was originally bestowed from the terraced or step-like appearance which is often found to belong to districts of ancient volcanic origin. Basalt, and numerous associated rocks of like kind—due to the agency of volcanic fire in former periods—come under the head of trap. There are extensive districts in the British Islands (in Scotland and Ireland) which exhibit trap formations, of which the well-known basaltic columns of the Giant's Causeway, on the coast of Antrim, and Fingal's Cave, in the island of Staffa, offer familiar examples. The third division, which consists of volcanic rocks, embraces the products of modern volcanic eruption, and is applied to the lavas and other matter ejected from the craters of active volcanoes within the historic period.

The geographical area occupied by rocks of igneous origin, though inferior to that of the sedimentary formations, is very considerable; and their importance as agents in modifying the aspect of the earth's surface renders them of the highest interest to the physical geographer. The consideration of modern volcanic action forms the subject of a future chapter. The trap rocks, products of ancient volcanic forces now extinct, impart, in general, a highly picturesque effect to the tracts of country in which they occur, and hence the scenery of such districts often possesses great attractions. Their undulating outline, step-like ascents, abrupt crags and cliffs, and detached conical eminences, present, for the most part, a much greater variety of scenic effect than is produced by those either of granitic or of volcanic origin; and the soil which is formed by their decomposition possesses, in general, great fertility. Granite, on the other hand, often exhibits bare and naked elevations, and the high plateaus which it forms in some districts are generally of monotonous and uninviting aspect, presenting little irregularity of outline, and but scantily covered with soil. Granitic rocks, however, form the basis of most of the higher mountain-ranges, and their solid masses enter more or less into the composition of most of the elevated or upheaved portions of the crust of the Earth. Granite appears in the highest summits of the Alps, and the loftiest ridges of the Himalaya system are composed of the same rock. In the great mountain-system of the New World, the Andes, though granite forms the basis of the whole, yet it is seldom met with at the higher elevations of the mountain-region—basalt and other products of later igneous origin crowning, for the most part, the loftiest summits of the chain. The mountains of the Scandinavian peninsula (Norway and Sweden) are almost wholly composed of granite, as are the Grampian Mountains in our own island.

IV.

THE HIGHLANDS OF THE OLD WORLD.

We have already noticed the fact, that the elevated masses of land, in either hemisphere, approach the exterior borders of the continents, presenting a short and rapid declivity towards the nearest sea, and a long slope towards the interior. This longer slope is directed, in the Old and New Worlds alike, towards the Atlantic and Arctic basins. The general direction of the elevated land-masses, however, differs in the case of the eastern from that of the western hemisphere. In the continents of the Old World the general direction of the highlands is east and west: in the continents of the New World, the highlands stretch from north to south. This direction is evidently connected with the general direction of the whole mass of land, and has resulted from the action of those forces by which the continents have assumed their present forms and reliefs. It has been often noticed, that in either hemisphere, the peninsulas point for the most part to the southward. Both Africa and South America (which are peninsulas in shape, though continental in point of magnitude) exemplify this on a large scale, as Italy, Greece, Hindostan, Corea, Kamschatka, Florida, and Lower California, do on a smaller proportion. Jutland, in Europe, and Yucatan, in the northern half of the New World, offer the most notable exceptions.

In the Old World, the following are instances of mountain-chains which lie in the general direction of east and west :—

In Europe.

Pyrenees	France and Spain.
Sierra Nevada	Spain.
Sierra Morena	Do.
Alps	Italy, Switzerland, & Germany.
Balkan Mountains	Turkey.
Caucasus	Russia.

IN ASIA.

Mount Taurus	Asia Minor.
Hindoo Koosh	Afghanistan.
Himalaya	India and Tibet.
Kuen-luen	Tibet and Chinese Turkestan.
Thian-shan	Chinese Turkestan & Mongolia.
Altai	Mongolia and Siberia.
Yablony, or Stanovoi	Siberia.
Pe-ling (Northern Mountains)	China.
Nan-ling (Southern Mountains)	Do.

IN AFRICA.

Mount Atlas	Morocco, Algeria, Tunis.
Kong Chain	Guinea.
Nieuw-veld Mountains	Cape Colony.

The mountains of Scandinavia, the Apennines, the Ural, the Lebanon ranges, and the Ghauts, are among examples in which the general law is reversed. The cordilleras of the Australian coast assume also a direction of north and south.

It has been already remarked that the plateaus of either continent follow the same general direction as that taken by the mountain-ranges. The latter, in fact, form a portion of the plateau-regions, which they enclose upon every side, and, regarded as affecting climate and other conditions in the economy of the natural world, are altogether subordinate to them in importance. Even the Himalayas, which exhibit in their snow-covered peaks, the loftiest elevations on the globe, are but the outer border of the Tibetan plateau; and the traveller who scales them from the southward—passing from the warm plains of the Ganges to the region of eternal snow—finds, when the crest of the mountain-wall is passed, that he is upon the summit of an immense plain. The irregular and peak-crowned rampart through which he has ascended forms the barrier of this vast and elevated region: its highest points rise considerably above the general level of the table-land, and, seen from below, appear to form the connecting links of a continuous mountain-chain. But, viewed as a part of the whole continuous mass of highland, they sink into unimportance as compared with its more solid extent and vastly greater proportions.

Plateaus.—The principal highland masses in the continents of the Old World are enumerated in the following list :—

In Asia.

Tibet	mean elevation	15,000 feet.
Mongolia	„ „	2000 to 4000 feet.
The Deccan	„ „	2000 to 3000 feet.
Afghanistan	„ „	6500 feet.
Persia	„ „	3000 feet.
Armenia	„ „	6000 feet.
Asia Minor	„ „	2000 to 4000 feet.
Arabia	„ „	3000 to 4000 feet.

In Europe.

Central Spain	mean elevation	2000 feet.
Bavaria	„ „	1600 feet.
Norway (southern part of)	„ „	4000 feet.

In Africa.

The Sahara, or Desert	mean elevation	1500 feet.
Abyssinia	„ „	6000 feet.
Southern interior	„ „	3000 feet.

The highland regions of the Old World coincide in great measure with the arid tracts of land which stretch through the African and Asiatic continents in the general direction of east and west, forming a vast belt of desert. Looking at the map, and commencing with the plateaus of interior Asia, we observe in succession, proceeding from east to west—the Gobi and adjacent deserts of Turkestan; the Great Indian Desert, (to the eastward of the Indus ;) the deserts of Beloochistan and Seistan; the Great Salt Desert of Persia; the Syrian and Arabian Deserts; the Egyptian and Nubian Deserts, between the Red Sea and the Nile; and, to the west of the last-named river, the vast expanse of the African Sahara, stretching to the very edge of the Atlantic Ocean.

This immense range of country, condemned to comparative aridity, and, as a consequence, thinly inhabited, constitutes, in all physical regards, one of the most remarkable portions

of the earth. Though comprehended, in a general sense, under the term "desert," it must not be supposed that these wide-spreading regions exhibit uniformity of physical aspect. The Gobi is a region of grassy plains, alternating in some instances with tracts of gravelly or sandy surface—whence the Chinese appellation of Shamo (*i.e.*, Sea of Sand) given to portions of it. But the Mongol shepherds pasture their herds over by far the larger portion of the vast plains which the Gobi embraces. The Indian Desert—an expanse of not less than 150,000 square miles—is not barren throughout. In its worst portions the desert here exhibits a series of sand-hills, divided by valleys in which scanty crops of grain may be raised during and immediately after the rainy season. But the rains are often slight, and irregular in their recurrence, and when the intense heat of summer has burnt up the scanty vegetation of shrubs and grass, which forms a covering to the hillocks, the fine sand is blown about by the wind, and hills and valleys alternately shift their places. The whole region then becomes an uninhabitable waste, which only the camel can cross with safety.

The Salt Desert of Persia is distinguished, as its name implies, by the saline efflorescence with which its surface is covered, and which causes the ground to sparkle in the distance under the rays of the sun. The Mesopotamian and Syrian Deserts are barren only during the season of summer heat, when the surface of the ground becomes parched, and clouds of dust, raised in whirlwinds from the arid soil, fill the air: at other seasons, when the thirsty soil is moistened by the rains of winter and early spring, they are covered with a carpet of verdure, and are bright with the hues of a countless variety of wild flowers. This is the brief "glory of the wilderness," destined to pass away with the returning heat of the summer sun.

The Syrian Desert passes to the southward into the arid regions which fill the greater part of the interior of the Arabian peninsula. The north-western corner of Arabia is a wilderness of naked rocks and barren mountain-chains, divided by the deep, (and, during eight months of the year, dry) beds of water-courses—the "wadies" of Arabian geography. This is the Arabia Petræa * of modern geography. But a large portion of interior Arabia, especially towards the south, consists of high and nearly waterless plains, with, in

* That is, the Rocky Arabia—Greek, *petra*, a rock.

many places, immense tracts of loose drift-sand. The sand constantly changes its position, and renders extensive districts uninhabitable. The appellation of "Roba-el-Khaly"—empty (or deserted) abode—given, as Burckhardt tells us, to the southern interior of the peninsula, supplies a striking indication of its characteristics. But the mountain-belt which borders Arabia on three sides includes watered and fertile valleys, in which the moistened soil yields corn and fruits in abundance.

The African desert—or "Sahara"—stretches through 3000 miles in the direction of east and west, and from eight hundred to upwards of a thousand miles in that of north and south. But the whole of this immense area is not equally arid. About the meridian of 14° east it is divided by the broad valley of Fezzan—a region partially redeemed from the prevailing sterility. To the eastward of Fezzan, the desert is less generally sterile than in its westerly division, and the "oases" which impart variety to its surface are of more frequent occurrence. Neither here nor in the western portion of the Sahara, however, does the desert consist of level plains, as is often supposed. High chains of naked rocks cross its surface in some places, and the traveller has to shape his course through their narrow and winding defiles. In other places, the shifting sand, of which entire hills are composed, obliterates all traces of a path, and compels the caravan which crosses the wilderness to depend for guidance upon observation of the sun or stars. The atmosphere, over the more parched and arid regions, presents at times the appearance of a red vapour, the heat of which, augmented by the burning wind known as the *simoom*, (or samiel,) is sometimes so great as to dry up the water carried for the use of the caravan, which, in such cases, is exposed to the imminent danger of perishing from thirst.

The oasis* of the desert is either the bed of a water-course, where the rains of winter are collected into a few hollows in the ground, or the depressed region surrounding a perennial spring, the water of which nourishes a verdure that becomes the more strikingly attractive from its contrast with the surrounding waste. The date-palm is everywhere the charac-

* From a Coptic term, signifying "a resting-place." The unfailing spring of water points out the natural resting-place of the traveller through the wilderness, and the position of the wells hence determines the direction of the routes which cross it. The Greeks likened the oasis, with its attractive verdure, surrounded by the wilderness, to an island in the midst of an ocean.

teristic of the oasis, in so far as vegetation is concerned, and thrives luxuriantly wherever water is found. Elsewhere, the only vegetation of the wilderness consists of a few thorny shrubs and briars, intermixed with an occasional and scanty covering of grass. The camel alone traverses, with comparative facility, the more arid portions of the Sahara, which, without its aid, would be to mankind an impassable barrier.

The table-lands of the New World comprehend:—

Utah (United States)............	mean	elevation,	5,000	feet.
Mexico..............................	„	„	7,000	„
Central America (Guatemala)	„	„	3,500	„
Quito (South America).........	„	„	9,000	„
Pasco (do.)	„	„	11,000	„
Titicaca (do.)	„	„	13,000	„
El-Despoblado (do.)	„	„	13,000	„
Brazil, interior, (do.)	„	„	1,500	„

These, however, occupy a much less extensive portion of the New World than the regions of correspondent formation do of the eastern half of the globe. It is in the Asiatic continent that the plateau-formation is seen in its fullest proportions. The highlands of Asia spread from the neighbourhood of the Indian Ocean over vast regions of the interior. Those of the New World are limited, for the most part, to the neighbourhood of the western coasts, and are compressed between the cordilleras of the mountain-region which borders the Pacific upon the side of America.

The influence which these elevated land-masses exert upon climate is surpassingly great. The interior plains of Mexico, which are traversed by the line of the northern tropic, yet enjoy a moderate (and even cool) temperature, while the low tract of country at their base, lying along the waters of the Mexican Gulf, suffers from the moist heats and pestilential vapours of the torrid zone. Even under the line of the equator, the inhabitants of the elevated valley of Quito luxuriate in a cool and equable atmosphere—a perpetual spring, the serenity of which is seldom interrupted, though storms expend their wildest rage within the regions below. In southern Asia, the elevated plateaus which belong to the mountain-region serve as sanatoriums, wherein the exhausted dweller in

the hot plains of India may recruit his strength, by inhaling a purer air, and enjoying the advantages of an invigorating breeze, unknown in such latitudes at lower heights.

MOUNTAINS.—Mountains exhibit every variety of form, and impart corresponding diversity of contour to the valleys which they enclose, or the lower heights which spread around their base. It is this variety, combined with other features of the landscape, which lends their well-known charm to the scenic aspect of mountain-lands. Some mountains rise with a steep ascent, their sides exhibiting bold escarpments, while others display gentler slopes, through which the valley passes gradually into the hill-side, and the hill into the mountain. The summits exhibit, in some cases, a rugged and precipitous crest, upon which are aggregated huge masses of rock, grouped wildly together; in others, they display a rounded or dome-shaped elevation, or (as in volcanic regions) present the figure of a cone. In numerous instances, the highest portion of the mountain exhibits a flat plain, or "table." The Table Mountain, at the Cape of Good Hope, is a well-known example. Mount Tabor, in the Holy Land, is an instance of like kind, as also are many of the hill-forts of the Deccan, so famous in the records of Indian warfare. In the case of these latter, the flat-topped hills, often crowned with solid masonry which might bid defiance to the strength of any other than European arms, rise steeply above the plains of Central India, their perpendicular walls of rock presenting examples of amazing natural strength.

The ravines, or defiles, which penetrate mountain-regions, and the high passes which rise with gradual ascent to the crest of the mountain-chain, and traverse its lofty elevations, display every possible variety of contour and aspect. The passes which traverse the Himalaya and the Andes rise, in some instances, to the surprising elevation of fifteen thousand feet and upwards. The passes of the Alps reach more than eleven thousand, and those of the Pyrenees nearly eight thousand feet, above the sea. In Norway, the summit of the mountain-region is a broad plain, or "field," over which the roads of that rugged land pass at elevations of four thousand feet.

Much importance attaches, historically as well as commer-

cially, to mountain-passes—the *pylæ*, or gates, (as they were termed by the ancients,) through which extensive regions are alone accessible. The road of the Simplon, constructed under the orders of Napoleon, first facilitated intercourse between the dwellers upon opposite sides of the Alps. The rugged defiles which traverse the chain of the Taurus, in the southern part of the Lesser Asia, constitute the approach to Syria, and have been marked by the footsteps of invading armies, in the periods of ancient and modern history alike In southern India, the high range of the Eastern Ghauts would forbid communication between the interior and the maritime tract which borders the bay of Bengal, were it not for the wild passes, which, "worn by mountain-torrents, and dark with jungle," lead from the table-land of the Mysore to the plains of the Carnatic. Nor does it require any considerable altitude to give importance, politically as well as in other regards, to the variety of external feature which hill-regions, and the roads which traverse them, exhibit. The moderate elevations of the Argonne sufficed to check the advance of an invading army, and proved the safeguard of revolutionary France, in 1792. Every campaign, alike in modern and in ancient warfare, furnishes instances of the importance which attaches to such features of natural scenery as are exhibited by hilly lands, even when their altitude is insignificant as compared with that of the great mountain-ranges of either continent.

The varieties of aspect above referred to are intimately connected with geological structure. Every kind of rock-formation—granite, trap, mountain-limestone, chalk, or alluvial deposit—has its characteristic external form, and imparts its distinguishing quality to the soil by which its strata are superficially covered. The rounded, swelling, and grass-covered hills, or *downs*, which belong to the chalk-region of south-eastern England, are a familiar example of this. The deep glens, abrupt precipices, and overhanging hill-sides, found in the districts which are composed of the older members of the stratified rock-formations—as in the mountain-districts of Cumberland, Wales, and the Highlands of Scotland—are an instance of an opposite kind. Gentle slopes, hills of more rounded form, and valleys of softer aspect and more extended limits, watered by streams which differ altogether in character from the mountain-torrents of bolder regions, distinguish those portions of England which are traversed

by the intermediate members of the sedimentary formations, —the various sandstones and limestones lower in order of position than the chalk. The limestone caverns of Derbyshire belong to the period of carboniferous deposit, and find an equivalent in the caves of Adelsberg amongst the Illyrian Alps, as well as in the similar formations of other regions.

The Himalaya Mountains, which surpass any others in altitude, may be regarded as a type of mountain-formations on the grandest scale. They form part of a series of highlands which stretch through the whole immense extent of southern Asia, and which reach their culminating elevation where they divide the Tibetan plateau from the fertile valley of the Ganges. The name of Himalaya—"dwelling of snow*" —is given to the gigantic mountain-wall which forms, through an extent of 1500 miles in the direction of east and west, the border of Northern India. The commencing portion of the mountain-region is throughout formed, along its southern base, by a chain of hills (known in Indian geography as the Siwalik Hills) which rise, in a well-defined line, above the plain. These hills vary in elevation from a few hundred to three or four thousand feet. Immediately below them, and stretching along their southern base, is a land of swampy country, about ten miles in breadth, covered with forest and jungle, and dreaded on account of its unhealthiness. This is known as the "Tarai,"—the abode of numberless wild animals, which find almost unmolested refuge amongst its thickly-wooded and pestilential recesses. The narrow belt of the Tarai extends along the southern base of the sub-Himalaya region through its entire length, and is one of the most characteristic features in the geography of India.

Above the entire line of hills here referred to, there occurs a depression, beyond which—at a further distance of from five to ten miles—the great mountain-region begins to rise, and stretches thence far to the northward, range above range. For a distance of sixty or seventy miles from the outer range, the mountains seldom exceed 10,000 feet in altitude. Thence they exhibit a more rapid ascent, and form at length that stupendous range of snowy peaks which surpass in elevation any other portions of the earth's surface.

The highest peaks of the Himalaya are met with in the eastern half of the mountain-system, and generally at from

* The meaning of the name, which is of Sanscrit origin.

about the eightieth to the ninetieth mile from the southern edge of the chain. Late measurements have shown that one of these peaks—Mount Everest, which so far as present knowledge extends is the culminating point of the globe—exceeds 29,000 feet in height. A vast number of them are upwards of 20,000, and several exceed 24,000 feet.* The greater peaks are not generally found on a continuous ridge, but grouped together in masses: these are separated one from the other by deep depressions, through which flow the streams that drain those parts of the contiguous plateau-region to the northward. The vast extent and stupendous elevation of the plateau—itself fifteen thousand feet above the sea-level—are, in truth, the most remarkable condition of the whole region. "After weeks," says Captain Strachey, "have been spent in traversing mountain after mountain, of the seeming interminable succession of which the eye begins to tire, while the incessant roar of the torrents that rush by begins to weary the ear, we are here suddenly arrested by seeing spread out before us a plain, that without sign of water, of vegetation, or of animal life, stretches away, as far as the eye can reach, in a north-westerly direction; behind which rise mountains that gradually fade away in the distance, with here and there only a peak lightly tipped with snow."

It is only by thus regarding the higher and so-called mountain-chains in connexion with the plateaus of which they form a part, that a true idea of their character can be realised. Distinct *chains* of mountains, in the common acceptation of the expression, have no existence. Neither the Himalaya nor the Kuen-lun, marked upon our maps of Asia, have any definite special existence as mountain-chains, apart from the general elevated mass of Tibet. "I no longer," says Dr Hooker, "consider the Himalaya as a continuous snowy chain of mountains, but as the snowed spurs of far higher unsnowed land behind, which higher land is protected from the snow by the peaks on the spurs that run south from it."

The snow-line on the Himalaya varies between 15,000 feet on the southern, and 18,000 feet on the northern side of the mountain-region. Glaciers abound in all those portions which rise above the snow-line, and some of them are of vast magnitude. The lowest level to which they have been observed to

* Mount Everest is in N. lat. 27° 59′, E. long. 86° 58′. Its exact height, deduced from the mean of several observations, is stated at 29,002 feet. The mountain called Kunchin-jinga, which ranks next in altitude, is 28,156 feet; Dhawalagiri, the third in order of height, is 26,826 feet.

descend is about 11,500 feet above the sea, and from that height to 12,000 feet is the ordinary elevation of their extremities. In those parts of the mountains which are to the northward of the great peaks, where the elevation of the snow-line is considerably increased, the lower extremities of the glaciers recede in a corresponding degree, the altitude at which they terminate being increased to about 16,000 feet.

The Alps are the great mountain-system of Europe, and though modelled on a scale of magnitude much below the great ranges of the Asiatic continent, they assume an aspect of superior importance when regarded in their influences on the destinies of the human race. During a long succession of ages, the chain of the Alps—a mountain-wall which extends, in semicircular direction, around the head of the Italian peninsula, protecting its rich plains from the less genial influences of a northerly sky—parted two worlds from one another. The fairest buds of civilisation had already opened under the Grecian and Hesperian skies, while scattered tribes of barbarians were yet wandering in the forests of the north. "How different," exclaims Heeren, "would have been the whole history of Europe, had the wall of the Alps, instead of being nearer the Mediterranean, been removed to the shores of the North Sea!" This boundary, it is true, is of less moment in our time, when the enterprising spirit of the European has built roads across the Alps, as it has found a path over the ocean; but it was of decisive importance for the age of antiquity. The north and the south were then physically, morally, and politically divided, and the mountain-chain long remained the bulwark of the one against the other. Julius Cæsar planted the Roman eagles upon the banks of the Rhine and beside the waters of the German Ocean, thereby removing the political landmarks of the Roman world. But under the later rulers of Rome, the Alps again became the virtual limit of the imperial power, and their natural strength served to delay for a time the overthrow of the declining empire at the hands of its rude invaders.

The highest summit of the Alpine system—Mont Blanc, situated upon the frontier of Savoy and Piedmont, and near the Swiss border—reaches 15,744 feet above the sea,—an altitude hardly more than half that of the culminating summits of the Himalaya. But the snow-line in the Alps descends to 8000

feet, and all the higher portions of the mountain-region are crowned by snow-covered peaks. In variety and magnificence of scenery, the Alps are probably inferior to no other mountain-system on the globe, and they are superior to most others in these regards. The lakes that lie embosomed within their valleys, the foaming torrents and waterfalls that descend their steep and wooded sides, and, more than all, the vast glaciers which originate within the snow-region and descend to the plains beneath, lend to the great mountain-system of the European continent scenic charms of the highest order. It is upon the northern face of the Alps that the larger glaciers are found: those on the Italian face of the mountain-crest are few in number, and of smaller proportions.

Much attention has been bestowed, of late years, upon the subject of *glaciers*, chiefly with a view to observe the true nature of the ice of which they are composed, and to determine their kind and rate of motion. The glacier is an *ice-stream* or river, originating in those parts of the mountain-region which lie above the snow-line, supplied from above by the snow which falls during each successive season, and most abundantly during the winter. It advances with constant (but unequal) motion down the valley—accompanied, both in front and upon either side, by a mass of loose stone, rock, and various débris, known by the name of a *moraine*. When the lower portion of the glacier recedes, as is often the case during summer, the moraine is left in advance of its course—an enduring indication of the furthest point which the ice-stream has reached. The glaciers of the Alps descend, in many instances, as low as between three and four thousand feet, advancing to the very border of the vineyard or the cornfield.* The lower extremity of the Mer de Glace (on the western face of Mont Blanc) is only 3667 feet above the sea.

The surface of the glacier is everywhere *crevassed*—that is, intersected by deep crevasses or rents, which vary from a few

* What gives to a glacier its most peculiar and characteristic feature is, that it does not belong exclusively or necessarily to the snowy region. "The snow disappears from its surface in summer as regularly as from that of the rocks which sustain its mass. It is the prolongation or outlet of the winter-world above: its gelid mass is protruded into the midst of warm and pine-clad slopes and greensward, and sometimes reaches even to the borders of cultivation. The very huts of the peasantry are sometimes invaded by this moving ice, and many persons now living have seen the full ears of corn touching the glacier, or gathered ripe cherries from the tree with one foot standing on the ice."—*Forbes: Travels through the Alps of Savoy.*

inches to many feet in breadth, and are often many hundred feet in depth. The direction of the crevasses is generally (but not uniformly) transverse to that of the glacier. In length, they sometimes stretch quite across the glacier, from one side to the other. Some of the crevasses on the Mer de Glace are probably 2000 feet in length. The crevasses appear to result from the downward movement of the whole body of the ice-stream over a surface which presents great irregularities. They are, in fact, rents or cracks in the moving body of the ice-current, and are in great measure renewed from year to year.

The ice of which the glacier is composed, exhibits, throughout the middle and lower portions of its course, a veined appearance—successive streaks of blue alternately with the general structure of the entire mass. These blue veins appear to result from the movement proper to the entire body of ice, accompanied by intense pressure exerted from above,—in the same way that a laminated or slaty structure is the result of intense pressure exerted on various kinds of rock formation. The direction of the veins is nearly vertical to the surface of the glacier, and they form successive lines which curve forward, in the direction of the glacier's motion. The upper portion of the glacier—above the snow-line—is known as the *nevé*: the ice of which the nevé is composed exhibits a texture less uniform and less compact than belongs to the middle and lower portions of the ice-stream. It consists of alternate layers of granular snow and hard ice.

The motion of the glacier exhibits perfect analogy to that of a river. Its rate of advance is greater in the centre than at the sides, and greater at the surface than towards the bottom. The retardation of the sides and bottom results from friction against the rocks with which the ice is there in contact. It moves faster in summer than in winter; but the motion is never wholly interrupted. The mean daily motion of the Mer de Glace, in different portions of its extent, has been ascertained to vary between nine inches and twenty-five inches. The average rate of motion, towards the lower part of the glacier, is, in summer, about 17 inches daily; this diminishes to 13½ inches during the winter. The average rate of motion belonging to the entire ice-stream is perhaps about 500 feet annually. The surface of the glacier undergoes continual changes of level, uniformly becoming depressed during the summer. This is owing mainly to the higher temperature of

that season, which thaws the surface of the ice, but is probably aided by other causes.*

The Scandinavian peninsula offers an example of a mountain-region wholly unlike those described above. The whole western, or Norwegian, side of the peninsula exhibits a mountain-wall, which rises precipitously above the adjacent ocean. The multitude of *fiords*, or narrow salt-water estuaries, which penetrate the coast of Norway, and admit the ocean into the heart of the mountain-region, are a characteristic feature of Scandinavian geography. It is principally on their shores, sheltered in some degree from the fury of the storms which rage over the neighbouring ocean, or expend their strength upon the naked mountain-plains above, that the towns and villages of this singular country are built. The summit of the mountain is here not a sharp peak, or lofty ridge, but a wide-spread, barren plain, or "field," † composed for the most part of gneiss and other rocks of crystalline texture, and upon which detached masses rise in the most fantastic forms. The whole of Norway is, in fact, one vast mountain, which presents an abrupt declivity to the sea, and on the other side exhibits a gradual inclination towards the eastward division of the peninsula. Norwegian valleys are rents or chasms in the whole vast mountain mass, and are altogether unlike the valleys of other lands. The snow-line is here found at an elevation which varies from between four and five thousand feet in the southern portion of the peninsula to a few hundred feet in the neighbourhood of the North Cape. There are snow-fields or glaciers of considerable extent in parts of the mountain-region.

* The theory of Professor Forbes, in regard to glaciers, is thus expressed, (Travels in the Alps of Savoy, p. 365):—"A glacier is an imperfect fluid, or a viscous body, which is urged down slopes of a certain inclination by the mutual pressure of its parts." This theory, in the belief of the present writer, fully satisfies the conditions of the case. It is, indeed, objected that the rigidity, and apparently unyielding nature, of ice—as seen in large masses—forbids our regarding it with correctness in the light of a semi-fluid, or viscous body. Hence Professor Tyndall, arguing on the facility with which ice, when fractured, becomes re-frozen by contact of its parts, (especially when accompanied by pressure,) proposes the theory of *fracture* and *re-gelation*, as accounting for the admitted movement of the glacier. But the plasticity, at least, of ice seems proved by the very nature of the ice-stream, and its continuity of movement is more in accordance with the motion of running water (though at an infinitely slower rate) than with that of a motion dependent on successive breakages and re-freezing.

† The Dovre-field, Hardanger-field, Lang-field, and other like names, distinguish portions of the Norwegian mountain-system.

V.

THE HIGHLANDS OF THE NEW WORLD.

The general direction of the highlands of the New World has been already referred to. The Andes—the great mountain-system of the South American continent—make nearer approach in altitude to the snow-covered Himalaya than any others of the mountains within the western half of the globe, and, prolonged as they are through an unbroken extent of four thousand miles, even surpass them in point of continuity.

The Andes exhibit three (or, towards their northernmost extremity, four) nearly parallel chains, or cordilleras. These become diminished, in the passage of the mountain-system through Peru and Bolivia, to two enclosing chains, between which are the loftiest table-lands of the New World. In Chili, the mountain-system is narrowed to a single chain, which finally terminates in the barren island-region of Tierra del Fuego and the adjacent rocks of Cape Horn, where it sinks beneath the waters of the Pacific.

The Columbian Andes include Chimborazo, 21,415 feet, at one time regarded as the highest elevation on the surface of the globe, besides many other lofty summits—several of them volcanoes—which border, upon either side, the high table-land of Quito. But the mountains that enclose the Peruvian and Bolivian plateaus attain a superior altitude, and contain a greater number of elevated summits than any other portion of the Andean system. The average elevation of the ranges is here from twelve to fourteen thousand feet, and the highest summits reach an additional altitude of eight or nine thousand feet. Among the stupendous masses which lie grouped around the table-land of Titicaca, between the 14th and 19th parallels, there are several which exceed 20,000 feet: Sahama, the highest measured amongst them, is 22,350 feet, and the summit of Lirima, further to the southward (lat. 19° 47′, long. 69° 12′) has been conjectured to reach 24,000 or 25,000 feet above the sea. If this estimate be correct, Lirima must be

regarded as the culminating summit of the New World. But the highest among the measured summits of the Andes is the mountain called Aconcagua, one of the many volcanic cones found within that portion of the mountain-system which forms the eastern border of Chili. The summit of Aconcagua is 23,944 feet above the sea. The entire range of the Chilian Andes exhibits a succession of lofty peaks, the average height of the mountain-crest being there at least twelve thousand feet. Several of the passes over this part of the chain are upwards of 12,000 feet above the sea.

In Patagonia, the mountain-system diminishes in altitude, its higher summits, however, still reaching between seven and eight thousand feet, until the chain declines, ere reaching Cape Horn, to less than half that altitude. The Patagonian Andes—unlike other parts of the chain—rise abruptly out of the waters of the ocean, which they immediately adjoin. Along the whole extent of Western Patagonia, the coast is indented by deep and narrow inlets, which penetrate within the mountain mass, in a similar manner to the fiords of the Norwegian sea-board. The islands which line this part of the coast—sometimes embraced under the name of the Patagonian archipelago — are portions of the mountain region, severed from the mainland by deep channels, upon either side of which there rise walls of nearly perpendicular rock. Similar deep channels divide the numerous islands which are comprehended under the appellation of Tierra del Fuego, that is, "Land of Fire"— a name inappropriately bestowed upon so cold and desolate a region.

The passes over the Andes rival those of the Himalaya in height—some of them attaining an altitude of 15,000 feet. Terribly hazardous, in some cases, is the passage through the wild and deep glens which they traverse, where the road consists only of a narrow mule-track along the steep face of a precipitous cliff, and when a single false step would precipitate the traveller into the abyss which yawns beneath. Nor is the road, in the greater number of cases, practicable even for mules, or anything more than a mere footpath. So great, indeed, are the impediments which this great mountain-chain interposes to commercial intercourse, that the productions belonging to the eastern slope of the cordillera may be conveyed thence to the shores of the Atlantic, a distance of 3000 miles, with infinitely greater facility, and economy both of time and money, than to the coasts of the Pacif-

Ocean, though the latter are less than a hundred miles distant. The city of Quito is, for all purposes of commerce, actually nearer to the Atlantic Ocean than to the Pacific, for the river Pastaza, a tributary of the Amazon, is navigable for 300-ton steamers to within 150 miles of Quito, and the eastern slope of the cordillera is comparatively easy of ascent; whereas the western descent of the mountains lies through a variety of lower ridges, so difficult of passage that goods are sometimes delayed a twelvemonth on the transit between Guayaquil, the chief port of the state of Ecuador, and Quito, its capital. So great are the influences which result from the facilities for intercommunication afforded by rivers and the difficulties interposed by mountain-chains!

Further to the south, however, the passes which traverse the mountain-system are more practicable of transit, and offer greater facilities for commerce. The San Francisco Pass, which traverses the Chilian Andes, in lat. 27 S., at an altitude of 15,000 feet, is never wholly blocked up by snow, and it has even been proposed to carry a line of railway over its summit. Most of the passes in that portion of the mountain-chain are blocked up by snow during three or four months of each year.

One important feature of the Andes—regarding the system as a whole—is their coincidence with a vast line of subterranean heat. In no other part of the world are there so many active volcanoes, and nowhere else is the destructive force of the earthquake experienced with so much frequency, or with such tremendous power. The country along the western foot of the Chilian and Peruvian Andes has, within comparatively recent periods, been repeatedly convulsed by violent earthquakes, resulting in the complete destruction of towns and other works of man, and on some occasions whole tracts of country, embracing many thousands of square miles, have had their levels permanently altered by these frightful shocks. It is in the Andes of Chili, and again in the immediate neighbourhood of the equator, that the number of active cones of eruption is greatest.

In this vast mountain-system—prolonged through more than sixty degrees of latitude—the conditions of climate are of course infinitely varied. These differences correspond not merely to successive heights above the sea, but also to distance from the equator. The general direction of the mountain-chains of the New World is attended in this regard by

results different from those that ensue in the case of ranges which, like those of the Asiatic continent, have a direction coincident with that of parallels of latitude, and hence experience at correspondent heights, similar (or nearly similar) conditions of climate throughout their extent. In the Andes of Quito, under the equator, the line of perpetual snow is reached at 15,800 feet above the sea. In the Bolivian Andes, it recedes to a greater altitude, owing probably to the increased breadth of the mountain region, and the greater breadth of the plateaus which it there embraces. The snow-line ranges, in that portion of the system, from 15,900 to upwards of 18,000 feet. In the Andes of Chili, it gradually declines from 14,000 to 6000 feet, with the successive advance into a more southern latitude, and on the shore of the Strait of Magellan descends as low as 3390 feet.

The Andes form a portion only of the masses of highland which border the Pacific coasts of the New World. In the narrow region of the Mexican isthmus—including under that name the entire tract which extends from the Gulf of Darien to the parallel of 28° N. latitude—the high-grounds fill up nearly the whole space between the Pacific and Atlantic oceans. The cordilleras which traverse the isthmus of Panama form an unbroken range, varying from 900 to 1600 feet in height, from which branch off a number of subsidiary ranges; the whole tract of country, to the top of the highest summits, being covered by a dense forest, with a growth of underwood so thick as to make it difficult to cut a way through. In Guatemala and the other states of Central America, the line of the highest peaks borders closely on the Pacific, while the plateau-region spreads over the larger portion of the interior. Many of the peaks are active volcanoes. The Mexican table-land—further to the north—exhibits numerous insulated volcanic cones, amongst which the mountain known as Popocatepetl reaches 17,773 feet, and the peak of Orizava (or Cilaltepetl) 17,373 feet above the sea. But as these mountains rise from a base which is elevated hardly less than nine thousand feet, their actual height, relatively to locality, is much less considerable.* The chain of the Sierra Madre, which stretches

* The terminal *tepetl*, found in the names of so many of the Mexican mountains, is, in the Aztec tongue, the native language of the Mexican Indians, a generic term applied to such mountain cones. Thus Popoca-tepetl signifies *smoking-mountain* (in allusion to its volcanic character); Cilal-tepetl, *star-mountain;* and Naucampa-tepetl, *rectangular* or *cubic mountain*.

though great part of Mexico in the direction of south-east and north-west, coincides with the general line of watershed between the two oceans; but it is only towards the upper portion of the valley of the Rio Grande del Norte, and to the northward of the 32d parallel, that the dividing mountains assume the true character of a lofty and well-defined system, and it is there that the Rocky Mountains commence.

The Rocky Mountains form the great dividing chain or axis of the North American continent, and are prolonged in a northwardly direction as far as the shores of the Polar Ocean. Their highest points are found between the parallels of 50° and 55°, where several of the summits reach elevations little (if at all) short of 16,000 feet. The more southwardly division of the chain contains several summits which are upwards of 11,000 feet. Towards the north, the mountains decline in height as they approach the waters of the Polar Sea.

Recent exploration has shown the existence of several available passes across the Rocky Mountains within that portion of the chain which traverses the British territory—that is, to the north of the 49th parallel. The most important of these is the Vermilion Pass, (lat. 51° 10′,) the crest of which is less than five thousand feet above the sea, while the adjacent mountains on the north side of the pass rise to nearly sixteen thousand feet. This pass promises to become of high importance in connexion with the gold-producing province of British Columbia, to which it forms the most available means of access from the eastward. The Vermilion Pass is a thousand feet lower than any other known pass over the mountain-system. The passes that traverse the chain within the territory of the United States lie at an altitude of 7000 feet and upwards—an elevation at which they are blocked up with snow during a lengthened period of each year.

Although situated, on the whole, towards the western side of the North American continent, the Rocky Mountains are yet from four to six hundred miles distant from the waters of the Pacific. The intervening space is filled by a succession of highlands, the most remarkable of which is the territory of Utah—the home of the Mormon community. This singular tract of country constitutes a region which is physically distinct from all the adjacent territories—shut in on every side by mountain-chains, and watered by a system of inland drainage, like some of the interior plateaus of Asia. The Great Salt Lake—on the shore of which the chief city of

the Mormon population is built—has no outlet to the sea, though lying at an elevation of 4200 feet. On its western side, the plateau of Utah is bounded by the chain of the Sierra Nevada, which divides it from the auriferous basin of the river Sacramento, and the State of California.

The highlands which adjoin the western or seaward slope of the Rocky Mountains, terminate in general towards the Pacific in detached mountain-chains, and elevated masses, through which the rivers that belong to the Pacific drainage of the continent pass on their way to the ocean, forming numerous falls as they break through the gorges of the mountain-region.

The Alleghany Mountains, though vastly inferior both in geographical extent and in altitude to the mountain-systems that belong to the western side of the New World, are yet of high importance. The Alleghany consists of a system of highlands—not a mere mountain-chain. It includes several narrow and parallel ridges—all of them running in the same general direction, (that is, north-east and south-west,) and divided by longitudinal valleys. The number of ridges varies from six to as many as twelve, the width of the whole mountain-region exceeding a hundred miles. The rivers which originate among these chains form numerous waterfalls in their passage from the high grounds into the plains below, often forcing their way through ravines of striking beauty.

The central axis of the Alleghany Mountains, throughout their length, is composed of gneiss and other primary rocks, which are flanked over an extensive area of the mountain-region by limestones of the carboniferous period. It is here, extending through the western division of Pennsylvania and Virginia, and into the adjoining States of Ohio, Kentucky, and Tennessee, that the most extensive of the great coal-fields of the United States is situated—a coal-field which, though it embraces an area of 14,000 square miles, is yet less than a fourth-part of the total area of the coal-fields that are comprehended within the territory of the great republic of the Western World.

VI.

LOWLAND-PLAINS

THE plateaus and mountain-regions of the globe occupy a large portion of its surface—perhaps more than half of the whole extent of the land—and their influence over its climate and other natural influences that affect mankind is very great. The highlands of the Old World—fitted by their physical attributes and condition to be the home of pastoral and nomade races—were among the regions earliest occupied by mankind. From the banks of the Euphrates and the primeval cities of the Assyrian plain,* the course of the shepherd-warrior—whether directed to the east or the west—led towards some of the elevated regions which stretch thence within the same (or nearly the same) degrees of latitude, and which, at least in a general sense, are under like conditions of climate. The highlands of Persia and Afghanistan, in the one direction, of Syria and the Lesser Asia, in the other, display abundant evidence, both in traditional and monumental records, of their early occupation by the family of man. From the one, the natural order of advance leads to the fertile plains of India; from the other, to the shores of the Mediterranean, whence is easy transit to the peninsulas and islands that lie beyond.

But if the highlands of the earth were early the dwelling-place of the shepherd-warrior, it was within the adjoining lowland-plains and fertile river-basins that the arts of civilisation were first called into being, that towns were built, that population became numerous, and that systems of social polity were developed. The lowland-plains of Asia and Europe constitute, in the present day, the most populous regions of the globe, and include by far the more numerous portion of the human race. The like regions in the New World are

* Gen. x. 10–12.

fast filling with inhabitants, as the redundant population of older lands is directed, in an ever-flowing stream, across the waters of the Atlantic.

The most important and extensive amongst the lowland-plains of the Old World are enumerated in the following list:—

IN ASIA.

1. Plain of the Euphrates and Tigris (the ancient Mesopotamia and Babylonia.)
2. Plain of Hindoostan, or Northern India.
3. Plain of China, embracing the north-east part of that country.
4. Plain of Siberia.
5. Plain of Turkestan.

Among lowland-regions of less importance are the plains of Pegu, Siam, and Tonquin, all within the Indo-Chinese peninsula, or India beyond the Ganges.

IN EUROPE.

1. The Great Eastern plain, embracing nearly the whole of Russia.
2. Plain of Hungary, embracing the middle portion of the valley of the Danube.
3. Plain of Wallachia and Bulgaria, or the Lower Danube.
4. Plain of Lombardy, or Northern Italy.
5. Plain of Languedoc, in the south of France.
6. Plain of Bohemia, or the basin of the Upper Elbe.

The limits and direction of these regions may be traced upon any ordinary map, by means of their coincidence with the great river-basins of the eastern hemisphere. They include the longer slope of the land, which, as pointed out in a previous chapter, is directed towards the north and north-west, as well as the less extensive low grounds which border the Indian and Pacific Oceans. The Siberian plain alone comprehends an area equal to that of the European continent, and the rivers by which it is watered are among the most considerable in the Old World. So vast an area, under other conditions of climate, might have become the home of populous nations, the seat of civilisation and empire. But its high latitudes, which involve the rigour of an arctic sky, con-

demn a large portion of Siberia to the condition of a sterile wilderness, and must prevent even its more favoured districts from being other than thinly inhabited. The dreary swamps and morasses of the *tundra*, which replace, during the brief summer of those latitudes, the plain of ice and snow, stretch along the shores of the Arctic Sea through a vast extent of this wide-spread region.

Conditions hardly more favourable belong to the extreme northern portion of the great plain of Europe, the slope of which is directed towards the White Sea and the Arctic basin. But a large portion of Eastern Europe is inclined towards a southerly sky, and is watered by rivers which have their outfall into the Black and Caspian Seas. The Volga, the longest of European rivers, belongs to the Caspian basin, the most depressed portion of the entire region.

STEPPES.—The south-eastern division of the European lowland, and the adjacent portions of Asia, constitute the region of the *steppes*. These occupy an immense portion of the empire of Russia, and are among the most characteristic of the physical features of the Old World.

The steppes are grassy plains—prairies, or meadows, they would be called in the New World—which occupy a vast belt of the European and Asiatic continents. They stretch eastward from the banks of the Dnieper, far into the heart of Asia—along the shores of the Caspian and Aral Seas, and as far as the banks of the great river Obi. Indeed, in so far as their grassy covering, and general level expanse—among the prime characteristics of the steppe-land — are concerned, a like region may be said to extend to the eastward through Central Asia, so far as the Great Wall of China, and the valley of the Amoor. This is the "land of grass" of the Mongol shepherd, the true home of the Tartar nations, whose descendants yet preserve in their songs the memory of their famous leader Timour—the Tamerlane of historic record. So vast is the extent of this grass-covered region, that a mounted horseman, it has been said, setting out from one of its extremities at the beginning of the year, and travelling day and night at his utmost speed, would find the season of spring elapse ere he reached its further limits.

The south-western portion only of the steppe-land falls within the limits of Europe. This exhibits an unbroken expanse of level plain,—fatiguing to the eye from its perfect

uniformity—dry and burnt up by excessive heat in summer, a pathless expanse of snow during the opposite season of the year. The steppe is only productive during the brief time that the thirsty soil is refreshed by the rains of spring and early summer. Its aspect is then, for a time, glowing and verdant; grass and wild flowers cover the earth with a carpet of varied and attractive hues, and the wild cattle and horses luxuriate in the abundant pasture. In the autumn, when the herbage has become dry and withered, the steppe sometimes exhibits a vast sheet of rolling flame, the grass being occasionally fired by accident, at other times intentionally, for the sake of the young crop which springs up through the ashes. The illusive phenomena of mirage—the result of atmospheric refraction, engendered by the intense dryness of the air—are of frequent occurrence in the steppe. Sometimes the eye is cheated by the semblance of a lake, which vanishes upon approach. In other instances, the traveller over these wild regions appears to see rising before him, and glittering through the dense mist which often prevails during the hours of mid-day heat, the towers and other buildings of a distant city. Spires, trees, bridges, rivers, all appear in picturesque combination, only to sink into confusion as they are approached. When the spot where the city of enchantment had seemed to stand is actually reached, there is found only the long dry grass, waving as elsewhere in the surrounding waste. The vast accumulation of dry sand on the surface gives rise to another phenomenon, of frequent occurrence on the steppe, resembling water-spouts upon the sea, excepting that the column is filled with dust instead of water. "Suppose the great flat steppe stretched out beneath the blue sky—nothing visible—no breath of air apparently stirring—the whole plain an embodiment of sultriness, silence, and calmness—when gradually rise in the distance six or eight columns of dust, like inverted cones, two or three hundred feet high, gliding and gliding along the plain in solemn company: they approach, they pass, and vanish again in the distance, like huge genii on some preternatural errand." *

Such is the region over which the semi-nomade tribes of Tartar shepherds, who constitute a fraction of the vast population of the Russian empire, pasture their herds. It is only here, within the limits of Europe, that the camel is successfully reared. Odessa, the great out-port of Southern Russia,

* The Crimea, &c. (London, 1855.)

stands almost on the edge of the steppe, and the whirlwinds of dust that pass through its streets, and constitute, during a portion of the year, one of its chief drawbacks as a place of residence, furnish obvious evidence of this proximity. The steppe includes two-thirds of the Crimean peninsula, the extreme south of which, however, is traversed by a hill-range of considerable elevation, and exhibits widely different features.

Beyond the Dnieper, the Don, and even the Volga, the same region of alternate grassy plains and sandy waste stretches far into the Asiatic continent. To the east and north of the Caspian and the Aral are the steppes over which roam the hordes of the Khirghiz. The names of Kara-koom and Kizil-koom,* given respectively to the sandy wastes which extend upon either side of the river Syr, or Jaxartes, are strikingly indicative of the general character of the tracts to which they are applied. A recent traveller thus describes the journey through these wild regions. "For many miles the sand was hard, like a floor, over which we pushed on at a rapid pace. After this we found it soft in places, and raised into thousands of little mounds by the wind. Our horses were now changed, and in an hour these mounds were passed, when we were again on a good surface, riding hard. . . . . Hour after hour went by, and our steeds had been changed a second time. . . . . In our route there was no change visible — it was still the same plain; there was not so much as a cloud floating in the air, that, by casting a shadow over the steppe, could give a slight variation to the scene. . . . . The whole horizon was swept with my glass, but neither man, animal, nor bird, could be seen. . . . . We rode on for several hours, but there was no change of scene. One spot was so like another that we seemed to make no progress. . . . . No landmark was visible, no rock protruded through the sterile soil; neither thorny shrub nor flowering plant appeared, to indicate the approach to a habitable region. All around was 'kizil-koom,'† (*red sand.*)"

The perfect solitude and unbroken silence of the desert are not less characteristic than its wearisome monotony of surface. No sound of bird or animal breaks the solemn stillness which reigns around; no trees expose their foliage to the

* Kara-koom, *black sand;* kizil-koom, *red sand.*

† Travels in Regions on the Upper and Lower Amoor, &c. By T. W. Atkinson. (London, 1860.)

influence of the wind. The course of the traveller is still onward, through the same apparently interminable waste. "Fourteen hours had passed, and still a desert was before us. The sun was just sinking below the horizon. The Khirghiz assured me that two hours more would take us to pastures and to water. . . . . It had not become quite dark, and the stars were shining brilliantly in the deep blue vault. My guides altered their course, going more to the south. On inquiring why they made this change, one of them pointed to a star, intimating that by that they must direct their course.

"We travelled onwards, sometimes glancing at the planets above, and then anxiously scanning the gloom around, in the hope of discovering the fire of some dwelling that would furnish food and water for our animals. Having ridden on in this manner for many miles, one of our men stopped suddenly, sprang from his horse, and discovered that we had reached vegetation. The horses became more lively, and increased their speed, by which the Khirghiz knew that water was not far off. In less than half an hour they plunged with us into a stream, and eagerly began to quench their terrible thirst, after their long and toilsome journey."

The features above described are those of the steppe region, regarded as a whole. But this aspect undergoes considerable variation in particular localities. The Lower Steppes, as those portions of the great plains which immediately border the Caspian are termed, exhibit a soil largely impregnated with saline particles, and contain numerous salt-water lakes. Some of these lakes furnish a large quantity of salt, derived by means of evaporation. This region resembles in aspect the dried-up bed of a sea. The Caspian, upon which it borders, occupies the lowest part of a depression below the general level of the earth's surface, its waters being 81 feet lower than those of the Black Sea. The extent of the Caspian appears to be gradually diminishing.

The features of the steppe-land, however, are exceptional to the general characteristics of the European plain, regarded as a whole. Large portions of its middle and western divisions possess a rich arable soil, and exhibit annually a waving

of corn. The geographical limits of the lowland region are marked, in the direction of north and south, by the Black Sea and the Arctic Ocean. The eastwardly portions of this vast level expanse stretch into the heart of Asia. In the west, it reaches the shores of the Baltic, and is thence prolonged, with narrower dimensions, through Northern Germany, and the low flats of Holland, until it terminates in the waters of the German Ocean. Throughout this vast extent, tertiary and recent formations prevail, and the abundant clays, sands, and gravels, give their character to the surface-soil. The plain lying to the south of the Baltic consists principally of sandy heaths, and contains, towards the sea-shore, a vast number of small lakes or *meers*.

The low shores of Holland—conquered from the sea by the persevering industry of the Dutch nation—furnish a conspicuous example of the sand-hills, or *dunes*, which are often found on low sandy coasts, and which owe their origin to the action of prevailing winds upon the loose drift-sand. Where no means are adopted to fix them to the soil, the sand-hills become agents of destruction, sometimes overwhelming whole villages in their slow but steady advance inland. But this is not the case in Holland, where the ingenuity of the Dutch has converted them from instruments of destruction into a means of national preservation. In some of the provinces of the Netherlands, a large portion of the land is actually lower than the level of high-water mark, and is therefore exposed (it might appear) to the ravages of the adjoining ocean. But from the channel of the Helder southward, the coast is protected by a line of broad dunes, or sand-hills, which are partially covered with grass or heath, and are in some places from forty to fifty feet in height. These have been formed by the natural process above adverted to, and still in operation: the prevalent sea-winds raise banks or ridges of sand at a short distance from the coast, which the inhabitants prevent from proceeding further inland, by sowing them with a kind of grass, (*arundo arenaria*,) the long roots of which bind the whole mass firmly together.

The district of the *Landes*, in the south-west corner of France, offers an example of the combined action of sand and sea, which is widely different from the above in its results. The coast here exhibits a line of shifting sands, backed towards the interior by a belt of pine-forests. For a length of nearly two hundred miles, from the mouth of the

Garonne to that of the Adour, there stretches along the extreme edge of the sea a range of hills composed of white sand, as fine as though it had been sifted for an hour-glass. Every gale changes the shape of these rolling masses of drift-sand. A strong wind from the land flings millions of tons of sand per hour into the sea, to be again washed up by the surf, flung upon the beach, and with the first Biscay gale blown in whirlwinds inland. A water hurricane from the west has been known to fill up with sand many square miles of shallow lake, driving the displaced waters inland, dispersing them amongst the pine-woods, flooding and frequently destroying the scattered hamlets of the people, and burying for ever their fields of millet and rye. The shepherds of the Landes pursue their avocation mounted upon stilts, which raise them above the reach of the sand-blasts. The pine-forests yield annually a large supply of resin, the only harvest of this wild region. Intermixed with the pine-forests, a chain of shallow and marshy lakes stretches in a direction parallel to the coast, and at a few miles inland.

The lowland-plains of the New World are on a scale of vast magnitude, and, if not superior in extent to those of the eastern hemisphere, yet bear a much larger proportion to the entire area of the land. They are watered, moreover, by the longest rivers of the globe, and enjoy, for the most part, conditions of situation and climate in the highest degree favourable to man. Both in North and South America, the whole central expanse of the continent exhibits a vast succession of lowland-plains, the only division between the different portions of which is that formed by the watersheds of its longer rivers —not always to be traced without difficulty, owing to the generally level nature of the entire plain.

In North America, the prairies; in South America, the tracts known as llanos, selvas, and pampas, are included within the lowland-region, and exhibit some of the most characteristic among the aspects of nature in the western world.

The *prairies* * coincide, in a general sense, with the middle and upper portion of the Mississippi valley, embracing the vast region which extends from the great lakes to the base of

* French, *prairie*, a meadow.

the Rocky Mountains. They are covered in their natural state with a rich herbage, and exhibit a waving sea of grass, several feet high. At intervals, towards the banks of the rivers, patches of forest vegetation break the uniformity of the prospect, but the prairie itself is destitute of trees, and (as the name implies) is merely a grassy plain, or meadow. Alternate forest and prairie constitute the great features of natural scenery in the New World. When the rich soil of the prairie-land is broken up by the plough—an operation which is rapidly progressing, year by year, within the western states of the American Union—it yields abundant crops of corn. There are, however, within the vast extent of the North American continent, immense regions which yet retain the aspect of the wilderness. It is within these regions that the buffalo roams, in vast herds, and that the native Indian hunter pursued his game ere the advancing footsteps of the white man had driven him from his haunts.

The *llanos*,* or *savannahs*, are vast grassy plains which occupy nearly the whole basin of the Orinoco river, excepting only towards its highest portion, when they are succeeded by wooded plains. The llanos resemble in general features the prairies of the Mississippi valley, but have for the most part a lower level, and (owing to the abundant rains of the torrid zone) are annually inundated by the rivers to an immense extent. Whole districts, embracing thousands of square miles, are annually converted, within the interior plains of South America, into lakes, or temporary seas of fresh water, to be rapidly evaporated under the burning rays of a vertical sun. At the close of the rainy season the llanos are covered with grass, and form rich natural pasture-grounds. During the prolonged season of drought which ensues, the verdure is entirely destroyed, and the parched earth opens in wide and deep crevices—again to be laid under water with the recommencement of the rains.

The *selvas*,† or forest-plains, belong to the valley of the Amazon, and include an immense area of Brazil, watered by the lower portion of the great stream, and its chief tributary, the Madera. Vast regions are here covered by an uninterrupted forest, composed of trees of giant growth, their boughs

* That is, *level fields*, Spanish.
† Portuguese, *selva*, a wood.

interlaced by immense creeping plants, and the ground beneath thickly covered with a dense growth of underwood. To the southward of the forest-region are vast grassy plains, which stretch in that direction into the valley of the Paraguay.

The *pampas*,* or plains of the Paraguay and Paraná valleys, exhibit the same luxuriant natural growth of herbaceous plants as other lowland-regions of the New World. They include an immense region, which stretches from the neighbourhood of the southern tropic far to the southward of the river Negro, (lat. 39° S.), and from the banks of the Paraná to the eastern base of the Andes. The pampas are variously covered with long coarse grass, mixed with wild oats, clover, and other herbage. The tract of country known by the name of El Gran Chaco,† immediately to the westward of the upper Paraguay, —scarcely tenanted excepting by wild beasts,—exhibits a luxuriant covering of grass, which springs from a soil possessed of the highest natural capabilities.

Further south, the plains that extend from Buenos Ayres to the foot of the Andes are covered, during great part of the year, with gigantic thistles, which grow to the height of seven or eight feet, and are so thick as to render the country almost impassable. For nine months of the year the thistles are here the predominant (and almost the sole) feature of the vegetable kingdom; but with the heats of summer they are burnt up, and their tall leafless stems are levelled to the ground by the powerful blast of the pampero, or south-west wind, which blows from the snowy ranges of the Andes, after which the ground is covered for a brief season with herbage. This is destined, with the returning spring, again to give place to the stronger vegetation which it had succeeded, and for a time supplanted.

* That is, *plains*, a native word in the Peruvian or Quichua language.
† Or Chacu—an Indian name for the lair of wild beasts.

VII.

RIVERS.

THE following terms, used in treating of rivers, require explanation.

The whole extent of country which is drained by any river, with its tributary streams, is called the basin of that river. The compound term *river-basin* is hence often used in order to express such areas of drainage. In like manner, it is usual to speak of the basin of the Mediterranean, or any other sea, as a term expressive of the whole area within which all the running waters are ultimately discharged into the sea referred to.

The term *watershed* (or water-parting) is used to express the rise of ground which divides the streams belonging to different areas of drainage. Every two adjacent river-basins are divided by a rise of ground upon the opposite slopes of which the waters flow in different directions, determined in accordance with the exact nature of either declivity. This rise of ground is the watershed.

Watersheds are of the most various character, as to elevation, amount of slope, and other conditions. They are formed in some cases by ranges of hills, or high mountain-chains, and in other instances by a rise of land so gentle as to be imperceptible except to the most careful scrutiny upon the ground itself, and to be traced with difficulty upon a map. It was long an error with geographers to regard watersheds as identical with mountain-chains—a fallacy which is even yet hardly exploded. A chain of hills may possess considerable elevation, and yet not constitute a watershed, for streams that have their origin in ground of inferior elevation may traverse the range, by means of openings which the agency of water has originally formed, and which their channels continually tend to deepen. The chalk hills in the south of

England are an example of this. The ranges known as the North and South Downs do not constitute watersheds. The line which divides the streams that run into the Thames from those flowing into the English Channel is found midway between either range, in ground of inferior average elevation, and belonging to a distinct geological formation. Even in the case of high mountain-chains—the Himalaya, for example—the line of watershed is not necessarily coincident with that of the highest peaks. The water-parting between the rivers of Northern India and the streams that flow towards the interior plains of the Asiatic continent is to the northward of the line of snowy peaks which form the highest portions of the Himalaya. The rivers find their way to the plains below through deep ravines which intersect the mountain system, transversely to its general direction.

It is hence an error to regard watersheds (as has sometimes been done) as the foundation of a geographical system, though they are undoubtedly of high importance, and may be studied with advantage.

The term *delta* is applied to the portions of land enclosed between the various arms into which many rivers divide immediately above their outlets to the sea. It was to the triangular piece of land at the mouth of the Nile that the Greeks—from its resemblance in shape to the fourth letter of their alphabet, Δ—first gave the term, since generalised. The Rhine, Danube, Indus, Ganges, Mississippi, and Orinoco, are among examples of rivers which form dèltas.

Rivers rank first in importance among the natural features of the globe, and are intimately connected with the history and condition of mankind. The course of nations may in many instances be traced along their advancing streams; and the great cities built upon their banks have constituted, in all ages, the seats of empire. The names of the Euphrates, the Tigris, the Nile, and the Tiber, are indissolubly associated in the mind with the greatness of Babylon and Nineveh, of Thebes and Memphis, and of the capital of the Roman world. It is the same in modern times. London, Paris, Vienna, St Petersburg, Calcutta, New York, Quebec, have the most intimate association of thought with the streams of the Thames, the Seine, the Danube, the Neva, the Ganges, the Hudson, and the St Lawrence.

Every circumstance concerning rivers is an object of in-

quiry. Their rise, length of channel, outlet, volume of water, rapidity of current, depth and consequent capability of navigation, are among the more obviously important considerations. Many of these are directly connected with the elevation of the ground in which their streams originate, and the geological character of the soil through which they flow. The streams that water highland-regions are torrents rather than rivers, while those that flow through the lower plains naturally possess a gentle current, and expand to a greater volume. The same stream exhibits, in many cases, an instance of either class of rivers, according as the upper or the lower portion of its course forms the object of regard. Between the Ganges of the mountain-region, ere it leaves the gorges and deep valleys of the Himalaya, and the Ganges of the Bengal plain, there is a wide difference in current and volume of water, as well as in other regards.

The average fall of a river's bed is indicated by the difference between the altitudes of its source and its outlet, compared with its length of channel, or development. But the amount of fall may differ widely in various parts of the river's course. The velocity of the Indus, in the lower part of its course, is not more than from two to two and a half miles per hour, though the upper portions of its valley are within the highest mountain-region of the globe. The current of the Tigris, which rises at an elevation of more than 5000 feet above the sea, and is traditionally famed for the swiftness of its stream, becomes very moderate below Bagdad, where it is often less than a mile per hour. The rapidity of the stream of the Euphrates varies similarly; in the depressions of the alluvial plain it is often not a mile an hour, while the upper portions of its course average from three to four miles. During the last seven hundred miles of the course of the Amazon, its fall is only twelve inches, or less than one-eleventh of an inch per mile.

The Volga, which rises in the plain of Eastern Europe, at the moderate elevation of 633 feet above the Caspian Sea, has an average inclination of less than four inches to the mile throughout its course of more than 2000 miles. The Rhone, on the other hand, which has its origin among the glaciers of the Alps, at a height of 5900 feet, passes thence to the lake of Geneva through a difference of level amounting to 3670 feet within a course of little more than a hundred miles. The river Dee, which rises at a height of 4060 feet,—probably

a greater elevation than that of any other river in the British Islands,—has a course of only eighty-seven miles to its outlet in the German Ocean, at the city of Aberdeen—showing an average declivity of 46 feet per mile.

The volume of water which rivers contain varies with many conditions, dependent upon the nature of the sources by which they are fed, and the amount of rain-fall which belongs to different portions of their beds. In arid countries, the so-called rivers are often mere surface-torrents, dependent on the rains, and exhibiting merely the dry beds of water-courses during the season of drought. The "wadies" of the Arabian Desert, and the "creeks" of interior Australia, are of this character. If not wholly dried up, the stream is either diminished during the summer, under such circumstances, to a mere thread, or is converted into a chain of ponds, produced by a small residue of water which remains collected in the deeper hollows of its bed.

In all warm countries, and especially those that fall within or near the tropics, where the seasons of drought and moisture are clearly defined, the contents of the river-beds undergo periodical fluctuation, with the absence or the abundance of rain. With the rainy season, the stream—swollen not merely by the rain-fall of its own immediate neighbourhood, but by the thousand rills which, from distant high grounds, contribute their water to its tributary channels of supply—overflows its bed, and inundates the adjoining plains. With the recurrence of the dry season, the waters again become confined to the limits of their proper channel. The violence of the rains in tropical countries produces extraordinary differences of this kind within periods of brief duration. In Australia, so great is the rain-fall at particular seasons, and of such sudden violence, as within a few hours to convert every gully into a running stream, and every rivulet into a foaming torrent.

The periodical melting of the snows adds greatly, in some cases, to the volume of rivers which have their origin in mountain-regions. The numberless torrents which descend the southern declivities of the Alps, and, with each returning summer, swell the streams of the Po and its chief tributaries, furnish examples of this.

The transporting power of water is very great, and the torrent-like streams of mountain-lands often effect, by the violence of their sudden floods, great changes in the asp

of the valley through which their waters are discharged. "It has been calculated that a velocity of three inches per second will tear up fine clay, that six inches will lift fine sand, eight inches sand as coarse as linseed, and twelve inches fine gravel; while it requires a velocity of twenty-four inches per second to sweep angular stones of the size of a hen's egg."* In the interior of the Australian continent, the beds of water-courses which are dry during half the year display evidence of the violence of the winter's flood in the masses of rock torn from the sides of their beds, and strewn along the valley.

The capability of rivers for navigation, and their consequent use as channels of inland traffic, together with the facilities of ingress or egress to shipping presented by their embouchures, are considerations possessed of the highest importance, in so far as direct utility to man is concerned. Measured by such regards, mere length of channel constitutes an imperfect standard by which to judge of a river's importance. Several among the longer rivers of the Asiatic and African continents, owing to their fluctuating volume of water, to the presence of "bars" which obstruct their entrance, or to other causes, are of less service to man than many streams which make an insignificant appearance upon the map of the world. In the giant streams of the New World, we meet, indeed, with examples of rivers whose navigable qualities extend through nearly the whole length of their amazing development. The Amazon is navigable by large vessels for a distance of 2000 miles above its outlet, and by vessels of smaller size, drawing not more than five or six feet of water, to the very foot of the mountain-region—a further distance of a thousand miles. The Mississippi is navigable for nearly 3000 miles, by the direct arm of the river, and by the Missouri branch to the Great Falls by which it leaves the Rocky Mountains—a distance little short of 4000 miles from the Mexican Gulf.

In all social and commercial regards, the Thames, the Mersey, and the Hudson, rank among the most important rivers of the globe. The commercial greatness of the British metropolis, of Liverpool, and of New York, is indissolubly connected with the streams upon which they respectively stand, the broad and deep outlets through which these reach the sea, and the capacious and secure harbours which they consequently form.

* Page: Advanced Text-book of Geology.

The Atlantic and Arctic basins receive by far the larger portion of the running waters of the globe. This naturally results from the fact of the longer slopes of the land being directed thitherward.* Nearly all the longer rivers of the New World, and a considerable number of those of the Old World, flow either into the Atlantic and its gulfs, or into the contiguous basin of the Arctic Ocean. The Mississippi, St Lawrence, Amazon, Orinoco, La Plata; the Nile, Senegal, Niger, Danube, Rhine, Northern Dwina, Obi, Yenesei, and the Lena, are instances. Of the rivers that belong to the Pacific basin, the two great Chinese streams, Yang-tsze and Hwang-ho, with the Amoor, are the most conspicuous examples in the Old World; the Oregon and Colorado, in the New. The basin of the Indian Ocean is the least extensive of the three in area of land-drainage, as well as in other regards: among the rivers that belong to it are the Indus, Ganges, Brahmapootra, and Irawady, with the Euphrates and Tigris, on the side of Asia; and the Zambesi, upon the coasts of the African continent.

The Old World includes, besides, an extensive region of inland-drainage—that is, a large area watered by rivers which have no outlet to the sea. Within this area is comprehended a large portion of the Asiatic and European continents, extending from within less than two hundred miles of the Baltic Sea on one side to the borders of China and Manchooria on the other, through nearly ninety degrees of longitude. The Caspian Sea and the lake of Aral receive the greater part of the running waters that belong to this extensive region, which embraces upwards of two millions of square miles. The Caspian Sea occupies its most depressed portion, and is 81 feet lower than the general level of the waters of the globe. The surface of the lake of Aral is 31 feet *above* the same level. Like the Caspian and the Aral, both of which are salt, the smaller lakes comprehended within this area are principally salt. The basin of lake Chad, in the heart of the African continent, exhibits, similarly, a system of river-drainage which has no outlet to the sea.

The New World exhibits, on a much less extensive scale, two regions of which the drainage is wholly inland. One of these is the great basin or plateau of Utah, to the west of the Rocky Mountains, which includes the Great Salt Lake, and the seat of the Mormon community. The other includes the basin of lake Titicaca, situated upon the highest plate-

* See page 16.

of the Peruvian Andes, and enclosed between their stupendous masses upon either side.* The waters of lake Titicaca are fresh, but the river Desaguadero, which issues thence, is finally lost in the salt marsh of Uros, to the south-east.

It deserves remark, how large a proportion of the river-drainage of Europe is received into inland seas. Considerably more than half of its entire area is watered by the rivers which discharge into the Black, Mediterranean, and Baltic Seas. Including the Caspian basin, we find that more than three-fourths of the running waters of the European continent are discharged, primarily, into inland seas.

The Mississippi, in North America, and the Amazon, in South America, surpass any other rivers on the globe, alike in length of channel and area of drainage.

The Mississippi, "father of waters"—such is the meaning of the name—rises in lake Itasca, within the heart of the great American plain, and has a southward course of 2400 miles to the Gulf of Mexico. Midway on this course, it receives on its right bank the longer stream of the Missouri, which comes from the Rocky Mountains, and flows 2500 miles (in the general direction of south-east) ere it joins the Mississippi. Measuring from the mouth of the Mississippi upward to the point of junction, and thence by the Missouri to the source of the latter, the whole length of river channel is upwards of 4000 miles. The navigation of the Mississippi proper exceeds 2000 miles in length, and by the Missouri arm is more than 3900 miles. The breadth of the river nowhere exceeds three quarters of a mile, and is seldom more than half a mile, even in the lower portion of its channel, excepting during periods of annual flood, when the waters cover a vast extent of the adjoining plain. The spread of the inundation is, however, limited by a range of high "bluffs" which bound the alluvial plain upon either side, at varying distances from the proper channel of the stream. Below the junction of the Ohio, this plain is from thirty to fifty miles across. In general, the river flows much nearer the base of the eastern bluffs than to those on the western side of the plain.

The vast flood of water which the Mississippi and Missouri, with their numerous tributaries, bring down to the sea, occasions frequent and considerable changes in the depth and other conditions of their channels. The water acts with de-

* See page 33.

structive force upon the soft alluvial soil, wearing away the banks, and depositing the material in the bed of the stream. The extensive banks, and even islands, which are thus formed undergo frequent changes, every successive season producing alterations in the river's bed.

The most important among the numerous tributaries of the Mississippi, next to the Missouri, is the Ohio, which comes from the Alleghany Mountains, and joins the left bank of the main stream, 200 miles below the junction of the Missouri. The Ohio has a course of 950 miles above the junction, and is highly important as a channel of navigation.

The whole area of the Mississippi basin is more than a million and a quarter of square miles.

The St Lawrence, though much inferior in length of course to the Mississippi, constitutes one of the most important features in the hydrography of the New World, on account of the great chain of lakes with which it is connected and of which it forms the outlet. These lakes—Superior, Michigan, Huron, Erie, and Ontario—have, together, an area of more than 90,000 square miles, which exceeds that of the island of Great Britain. The river St Lawrence, which issues from the lower extremity of Lake Ontario, carries their superfluous waters to the sea, and becomes, in the latter part of its channel, a vast estuary, which gradually increases from twenty-five to a hundred miles in breadth.

The great lakes of the St Lawrence basin indicate a descent in the general level of its waters which is very gradual until Lake Erie—the lowest but one of their number—is passed. Thence to Lake Ontario the descent is very considerable. The surface of Lake Superior is 596 feet above the level of the sea. Lakes Michigan and Huron are only eighteen feet lower in level, and the surface of Lake Erie corresponds to a further depression of not more than thirteen feet. But between the surface of Lakes Erie and Ontario the difference of level amounts to more than three hundred feet, and the river Niagara, which connects them, is precipitated midway between the two lakes down the ledge of rock which forms the well-known Falls of that name. From the lower extremity of Lake Ontario to the city of Quebec, (where the broader part of its estuary begins,) the declivity in the channel of the St Lawrence is very considerable,—amounting to an average of eight inches per mile—and the numerous rocks which occur in its bed give rise

frequent and dangerous rapids. At the city of Montreal, where the Victoria Railway Bridge—the most stupendous amongst works of modern engineering—crosses the St Lawrence, the river is 6540 feet (or a mile and a quarter) in width, and flows at the rate of ten miles an hour. During several months of each year it is covered with a coating of ice eight feet thick, and when this breaks up, enormous blocks of ice are carried down the stream with almost resistless force. The Ottawa, which joins the St Lawrence on its left bank above Montreal, is the most considerable of its tributaries, and exhibits like characteristics. The channels both of the St Lawrence and the Ottawa open out, at intervals, into broad and lake-like expanses, studded with a multitude of islets, of every variety of form, and covered with a rich luxuriance of vegetable growth.

The river Amazon, which waters the great South American plain, has a length of channel which nearly equals that of the Mississippi, and waters a still more extensive area of country, its basin embracing two and a half millions of square miles. The river Maranon, which rises in the small lake of Lauricocha, among the high plateaus of the Peruvian Andes, is generally regarded as the main stream of the Amazon, though the Ucayali, and others of its tributaries, which come from a more southern source, are of equal (or perhaps greater) length. The Madera, which unites its waters to those of the Amazon 700 miles before the latter reaches the sea, has a length of more than 2000 miles above the junction, and several others among its tributaries would be accounted rivers of first-rate magnitude in any other region. The breadth of the Amazon increases in the lower portion of its course from five miles to upwards of fifty miles.

The Orinoco, another of the great South American rivers, exhibits the curious feature of a bifurcation in its stream, throwing off from the main channel a branch which joins the river Negro, an affluent of the Amazon. This branch, which bears the name of Casiquiare, leaves the Orinoco about 130 miles below the source of the latter, amidst the mountains of Guiana, and has a length of nearly 200 miles before it joins the river Negro. Two great river basins are thus united by natural means, so that a boat might pass from the mouth of the Orinoco into the river Negro, thence into the on, and down the latter stream to its outlet,—thus

making the circuit of a large portion of the South American continent, and passing round the extensive region of the Guiana mountain-system. Humboldt, in 1800, ascended the Casiquiare; and Schomburgk, thirty-nine years later, descended its stream, which is upwards of five hundred yards in width.

Many of the river basins of the New World, both in North and South America, exhibit near approach in the head-waters of their smaller tributary streams, and are divided by ground of so little elevation as to be laid under water during seasons of inundation. A narrow portage of three miles, consisting of grassy plain, alone divides the Aguapehy, one of the small tributaries of the upper Paraguay, from a similar affluent of the Guapore River, one of the main sources of the Madera. The basins of the Amazon and the La Plata are thus capable of easy union with one another, and when the savannahs are temporarily laid under water by the rains, the canoes of the Indians actually pass from the one into the other. In North America, the basins of the Mackenzie and the Churchill—the former flowing into the Arctic Sea, the latter into Hudson Bay—are united by means of Lake Wollaston, which lies exactly along the line of water-parting between them. From one extremity of Lake Wollaston there issues a stream which flows into Lake Athabasca, and thus passes (by way of Slave River and Great Slave Lake) into the Mackenzie: the opposite extremity of the lake gives issue to a stream which enters Deer Lake, the waters of which communicate with the Churchill. Again, the basin of Lake Winnipeg, (which is united by means of the river Nelson to Hudson Bay,) possesses like facilities of communication with the vast plains of the Mississippi. The upper affluents of the Red River, which enters Lake Winnipeg from the south, are at one point only divided by two miles of prairie from the head-waters of the St Peter's River, an affluent of the Mississippi. Facts such as these are not a little curious, regarded merely as among the truths of physical geography, and may at no distant future, as population spreads over the vast regions which lie to the west of the great lakes of the North American plain, become of high importance in a commercial point of view.

The great river of China—Yang-tsze-kiang—takes the first place among the rivers of the Old World. It issues from the mountain-region of Tibet, and has a course of 3200 miles befor

it reaches the sea, the latter portion of its stream flowing through a rich alluvial plain, the most fertile and populous portion of the Chinese dominions. In 1858, the Yang-tsze was ascended by a fleet of English steamers (one of them drawing sixteen feet of water) to a distance of more than six hundred miles above the sea. Frequent changes take place in the islands and banks that occur in its bed, the result of the vast quantity of sediment with which its immense volume of water is charged, and the great force of the stream. Great, however, as these are, they are inferior in extent to those which affect the channel of the Hwang-ho, or Yellow River. The latter stream (two thousand six hundred miles in length) has, within a recent period, burst through the artificially-formed mounds which the continued deposit of ages had rendered necessary for the confinement of its channel, and has opened for itself a new course into the gulf of Pe-che-lee, which it now enters at a distance of two hundred miles to the northward of its former embouchure. In the course of this change it has destroyed a large portion of the Imperial Canal, (hitherto the great highway for the conveyance of grain to the Chinese metropolis,) and has spread devastation and ruin along its course.

The Nile—amongst rivers of the Old World—possesses features of high interest, historical as well as geographical, and has perhaps commanded, through a long course of ages, a fuller share of the inquiring attention of mankind than any other river, or than any other among the natural features of the globe. This is due in great measure to the mystery which even yet attaches to its origin, and the periodical rise of its waters. The source of the longer arm of the Nile—that is, the White River, or Bahr-el-Abiad—is yet unvisited, though recent exploration lends some probability to the supposition that it issues from the large lake of Nyanza, lying immediately south of the equator, at an elevation of 3750 feet. The White River, however, has been ascended in boats as high as the latitude of 3° north, so that the total length of the Nile, by this arm, is probably not less than 3000 miles. Through fourteen hundred miles of this course, from the junction of the Tacazze downward to the sea, the Nile does not receive a single tributary, but continues to flow onward, a broad and never-failing stream, until its final outlet in the Mediterranean. The basin of the middle and lower Nile is hence of exceedingly

narrow limits, being, in fact, confined to the immediate course of the stream, and the adjacent tract periodically inundated by its waters.

The region over which the annual inundations of the Nile extend is marked by well-defined limits. A chain of high rocks, from eight to nine hundred feet in elevation, accompanies either bank of the river through Nubia and Egypt, only terminating in the latter country at the commencement of the Delta, where the Nile, hitherto a single stream, divides into the Rosetta and Damietta branches. The width of the valley between these bordering chains of rock gradually increases from less than a mile in Nubia to as much as ten or twelve miles in the middle portion of Egypt. The inundations of the river, and the fertilising deposit which they leave upon the soil, are strictly limited to this valley, excepting in the broader plain of the Delta, where, from the absence of the bordering hills, they spread over a wider range of country, the surface of which is composed of alluvial deposit from the waters of the great river.

The rise of the Nile no doubt results from periodical rains in the countries of its origin—that is, the regions lying south of Abyssinia; but until its source shall have been visited, the precise nature of these, and the varying amount of rise, are not capable of complete explanation. At Cairo, (a short distance above the head of the Delta,) the river begins to rise about the end of June, and continues to increase daily until towards the close of September, at which time nearly the whole valley is under water, and the greater part of the plains of the Delta are covered with the inundation. It then, after remaining stationary for a few days, retires gradually within its proper channel, leaving on the ground which it has covered the fertilising slime or Nile-mud, to which the abundant harvests of Egypt are wholly due. In seasons when, as is occasionally the case, the waters fail to reach their proper height, and consequently do not remain sufficiently long upon the ground, a failure in the harvest is the certain result.

The phenomenon of the *bore*, or *egre*, which in many instances occurs at the mouths of rivers, demands a brief notice. This consists in a tidal wave, which, under certain conditions, rolls up the channel of the river with a velocity so great as to overpower the descending stream, advancing in many cases with a noise like the rolling of distant thund

and not unfrequently occasioning serious destruction to any shipping that is exposed to its influence. In the case of some rivers, the *bore* forms a head-wave which rises far above the ordinary level of the stream, and rolls on with irresistible force. The Indus is a conspicuous example of this phenomenon. On a scale of less extent, the Solway Frith, the estuary of the river Severn, and the mouth of the Trent, exhibit like instances on our own coasts.* The estuary of the river upon which the Chinese city of Hang-chow is situated exhibits this phenomenon, at the period of the autumnal equinox, in almost unexampled grandeur. "Imagine an estuary four or five miles in width, the tide rising, and at first presenting the appearance of a white line, and gradually approaching with the noise of thunder, and by degrees rising until it becomes a wall four or five miles across, and twenty feet in height, coming up almost with the velocity of a cannon ball." The vast amount of shipping-craft belonging to Hang-chow are obliged to put out into the stream to meet the egre, for if they were to remain in-shore they would infallibly be crushed; when they meet it, they rise over the advancing wave, and escape the temporary danger. The egre is spent about ten miles above Hang-chow.†

In the Western World, the giant river Amazon offers a parallel (perhaps even superior) example of the phenomenon, there known as the *pirorôco.* In winter, when the spring-tides are highest, the pirorôco breaks with terrific force, often sinking or dashing to pieces boats that have been incautiously left in shallow water. The devastation occasioned in its course is seen in the uprooted trees which line the shores of the stream, and the high mud-banks where the earth has been washed away.‡

* At spring-tides there is a very strong bore in the Trent, the water rising at its mouth to the height of six or eight feet above the ordinary surface, and rolling in a large mass up the river.

† Dr Macgowan: Proceedings of Royal Geographical Society, vol. iv., p. 62.

‡ Wallace: Narrative of Travels on the Amazon and River Negro.—The explanation ordinarily given of the bore, which refers it to the meeting of the tidal and fresh-water currents—a contest between the sea god and the river god—are not strictly correct. The phenomenon is simply due to the strength and velocity of the wave engendered by the flood-tide, obstructed by the resistance occasioned by shoals at the entrance of the stream. When the tides are low, or the entrance of the river very deep, no obstruction to the flow of the tide-wave ensues. It is only in cases where there is a peculiar formation of the bottom, and not merely a narrowing and widening in the channel of a tidal stream, that the bore is occasioned.

In the following tables the names of the principal rivers of either continent are given, with the length of each, in English miles, and the estimated area of its basin, in English square miles. The rivers are arranged in the order of the seas into which they flow:—

RIVERS OF EUROPE.

	Length.	Area of Basin.
Flowing into the Caspian Sea—		
Volga, (through Russia,)	2200	520,000
Flowing into the Black Sea (including Sea of Azov)—		
Danube, (Germany, Hungary, and Turkey,)	1630	310,000
Dniester, (Austria and Russia,)	700	31,000
Dnieper, (Russia,)	1200	200,000
Don, (Do.)	1100	205,000
Kouban (Do.)	480	23,000
Flowing into the Baltic Sea—		
Oder, (Germany,)	550	53,000
Vistula, (Poland and Prussia,)	630	76,000
Niemen, (Russia and Prussia,)	400	43,000
Dwina, (Russia,)	550	45,000
Neva, (Do.)	40	91,000
Tornea, (Sweden,)	350	
Dal, (Do.)	350	
Flowing into the Mediterranean—		
Xucar, (Spain,)	250	6,400
Ebro, (Do.)	420	34,000
Rhone, (Switzerland and France,)	490	38,000
Arno, (Italy,)	150	2,900
Tiber, (Do.)	210	6,300
Po, (Do.)	450	40,000
Adige, (Do.)	250	
Vardar, (Turkey,)	200	
Struma, (Do.)	250	
Maritza, (Do.)	320	17,500
Flowing into the Arctic Ocean (including White Sea)—		
Petchora, (Russia,)	900	100,000
Mezen, (Do.)	480	
Dwina, (Do.)	760	144,000
Onega, (Do.)	380	
Flowing into the Atlantic Ocean—		
Glommen, (Norway,)	400	16,500
Gota, (Sweden,)	70	
Elbe, (Germany,)	690	57,000
Weser, (Do.)	380	17,800
Rhine, (Switzerland, Germany, Holland,)	760	88,800
Meuse, (France, Belgium, Holland,)	550	

RIVERS OF EUROPE—*continued.*

	Length.	Area of Basin.
Scheldt, (France, Belgium,)	250	8,700
Seine, (France,)	430	30,000
Loire, (Do.)	570	48,000
Garonne, (Do.)	350	33,000
Minho, (Spain,)	200	6,300
Douro, (Spain, Portugal,)	460	39,000
Mondego, (Portugal,)	120	2,700
Tagus, (Spain, Portugal,)	510	34,000
Guadiana, (Do. Do.)	450	26,000
Guadalquivir, (Spain,)	290	20,000

Rivers of the British Islands—

Thames, (England,)	215	6,160
Severn, (Do.)	240	5,540
Humber, { Ouse, (Do.)	150	9,950
Humber, { Trent, (Do.)	180	
Mersey, (Do.)	70	1,748
Tweed, (Scotland,)	96	1,870
Tay, (Do.)	100	2,400
Clyde, (Do.)	98	1,580
Shannon, (Ireland,)	224	7,000

RIVERS OF ASIA.

Flowing into the Arctic Ocean—

Obi, (Siberia,)	2600	1,250,000
Yenesei, (Do.)	2900	1,110,000
Lena, (Do.)	2500	960,000

Flowing into the Pacific Ocean—

Amoor, (Manchooria,)	2300	900,000
Pei-ho, (China,)	250	
Hwang-ho, (Do.)	2600	400,000
Yang-tsze-kiang, (Do.)	3200	760,000
Choo-kiang, (Do.)	1100	
May-kuang, or Mekon, (Anam, Cambodia.)		
Meinam, (Siam,)	900	

Flowing into the Indian Ocean—

Irawady, (Burmah, Pegu,)	1200	
Brahmapootra, (Assam, India,)	930	
Ganges, (India,)	1500	420,000
Mahanuddy, (Do.)	240	
Godavery, (Do.)	900	
Krishna, (Do.)	800	
Cauvery, (Do.)	470	
Tapty, (Do.)	440	
Nerbudda, (Do.)	800	

	Length.	Area of Basin.
Indus, (India,)	1700	400,000
Tigris, (Turkey,)	1140	230,000
Euphrates, (Do.)	1700	

Flowing into the Mediterranean Sea—

Orontes, (Syria,)	200	
Jyhoon, ancient Pyramus, (Asia Minor,)	250	
Syhoon, ancient Sarus, (Do.)	250	
Mendere, ancient Mæander, (Do.)	230	

Flowing into the Black Sea—

Kizil Irmak, ancient Halys,	500	30,000

Flowing into the Caspian Sea—

Kour, ancient Cyrus, (Armenia,)	550	72,000
Aras, ancient Araxes, (Do.)	520	

Flowing into the Sea of Aral—

Amoo, or Oxus, (Turkestan,)	1300	
Syr, or Jaxartes, (Do.)	1150	

Rivers of Africa.

Flowing into the Mediterranean—

Nile, (Abyssinia, Nubia, Egypt,)	3000	

Flowing into the Atlantic Ocean—

Senegal, (Western Africa,)	900	80,000
Gambia, (Do.)	650	30,000
Niger, (Soudan,)	2300	
Congo, or Zaire, (Do.)		
Orange, or Gariep, (South Africa,)	1000	300,000

Flowing into the Indian Ocean—

Zambesi.

Rivers of Australia.

Flowing into the Southern Ocean—

Murray, (New South Wales, Victoria, and South Australia,)	1200	200,000

RIVERS OF AUSTRALIA—*continued.*

Flowing into the Pacific Ocean—	Length.	Area of Basin.
Hawkesbury, (New South Wales,)	230	
Hunter, (Do.)	200	
Clarence, (Do.)	170	
Brisbane, (Queensland,)	130	

RIVERS OF NORTH AMERICA.

Flowing into the Atlantic Ocean—

Mississippi, main stream, (United States,)	2400	1,300,000
(Do.) by Missouri arm, (Do.)	4000	
St Lawrence, (Canada,)	2000	410,000
Nelson, or Saskatchewan, (Hudson Bay Territory,)	1400	
Churchill, or Missinippi, (Do.)	900	
St John, (New Brunswick)	410	22,000
Connecticut, (United States,)	400	11,000
Hudson, (Do.)	325	14,000
Delaware, (Do)	300	12,000
Susquehanna, (Do.)	450	
Potomac, (Do.)	400	
James, (Do.)	450	
Roanoke, (Do.)	350	
Pedee, (Do.)	350	
Santee, (Do.)	350	
Savannah, (Do.)	400	
Alatamaha, (Do.)	400	
Apalachicola, (Do.)	600	
Mobile, (Do.)	550	
Grande del Norte, (United States and Mexico,)	1400	245,000
San Juan, (Central America,)	120	

Flowing into the Arctic Ocean—

Mackenzie, (Hudson Bay Territory,)	2160	600,000
Coppermine, (Do.)	450	
Back, (Do.)	700	

Flowing into the Pacific Ocean—

Fraser, (British Columbia,)	600	98,000
Columbia, (British Columbia and United States,)	750	265,000
Sacramento, (United States,)	420	63,000
Colorado, (Do.)	840	230,000

Rivers of South America.

Flowing into the Atlantic Ocean—	Length.	Area of Basin.
Amazon, (Peru, Brazil,)	3900	2,500,000
Orinoco, (Venezuela,)	1200	400,000
La Plata, { Parana, (Brazil, La Plata,)	2350	1,240,000
La Plata, { Uruguay, (Do. Do.)	800	
Atrato, (New Granada,)	800	
Magdalena, (Do.)	860	98,000
Essequibo, (Guiana,)	600	84,000
Demerara, (Do.)	200	
Berbice, (Do.)	360	
Corentyn, (Do.)	470	
Surinam, (Do.)	350	
Maroni, (Do.)	400	
Maranhao, (Brazil,)	360	
Paranahyba, (Do.)	750	
San Francisco, (Do.)	1500	254,000
Grande do Belmonte, (Do.)	500	
Colorado, (La Plata,)	600	
Negro, (Do.)	800	

Flowing into the Pacific Ocean—	Length.
Biobio, (Chili,)	180
Maypu, (Do.)	160

Lakes.—Lakes are in most cases connected with rivers, either as occurring in the course of river-valleys, or as constituting the ultimate recipients of running streams. They owe their formation, in the vastly greater number of cases, to the agency of running water, in combination with the characteristic contour and relief of the land within particular districts. Many of the basin-shaped expanses which occur in hilly regions have been at some former period the beds of lakes, which have become drained of their waters, either by a sudden and violent bursting of the barrier which confined them, or by the slower agency of running streams in eroding the softer strata of the soil. Some lakes consist merely of hollow receptacles for the collection of rains, and neither receive nor discharge any stream of water. The lakes that are found, in some instances, within the craters of extinct and dormant volcanoes are of this description. But in by much the greater number of cases, lakes are connected with running streams, either in the way of ingress or egress, or both combined. The lakes in our own island—Windermere, Ulleswater, and others—are examples of this. Each of them receives one

or more streams from the surrounding high grounds, and gives issue to a stream at the lower extremity of its basin. A constant current is thus generated through the whole body of water, which preserves its freshness and purity.

One important classification of lakes—and perhaps the most important—is into *fresh-water* lakes, and those of which the water is *salt*. The former class includes all (or nearly all) lakes that discharge a stream of water—that is, all lakes which possess an outlet. The latter comprehends those lakes which have no channel of discharge—that is, no outlet for their waters. Windermere, Loch Lomond, the Lake of Geneva, are among examples of the former class: the Dead Sea, the Lake of Aral, and the Caspian Sea, (which is only distinguished by the appellation of "Sea" from its superior magnitude,) are of the latter description. Yet the classification of lakes into fresh and salt cannot be regarded as wholly dependent upon the question of outlet. Lake Chad, in the heart of the African continent, is a body of fresh water; but it has no outlet, though receiving the waters of the Shary, the Yeou, and other considerable streams. The exceptions, however, are exceedingly rare, and, as a general rule, it may be said that lakes which discharge a running stream are fresh, while those that have no outlet are salt.

The depth of lakes undergoes a gradual diminution, from the continued deposition of sediment in their beds, as well as, in some instances, from a secular contraction in the area covered by their waters. The Rhone enters the upper end of the Lake of Geneva as a muddy torrent, and re-issues from its lower extremity as a limpid stream, having deposited in the bed of the lake the sediment and other impurities with which its waters were charged. In greater or less degree, the same cause operates in the case of all lakes into which running streams discharge. The contraction in the area of bodies of inland water is exemplified in the case of the Caspian, the extent of which appears to have sensibly diminished within the historic period, owing, probably, to excess of evaporation over the influx of water from the rivers which it receives.

No other part of the world exhibits fresh-water lakes on so extensive a scale as the North American continent. Besides the great inland seas that belong to the basin of the St Lawrence, all the northern part of the great plain—from the shores of Hudson Bay to the foot of the Rocky Mountains—exhibits a labyrinth of lakes and connecting river-channels.

South America is remarkably deficient in lakes: that of Titicaca, on the highest plateau of the Andes, is the most considerable. The largest fresh-water lake in the Old World is Lake Baikal, in Siberia—the "Holy Sea" of the Russians, by whom its waters are regarded with superstitious reverence. The African continent, though in many parts arid, contains some extensive collections of inland water, two of which—Lakes Nyanza and Tanganyika—have been recently visited for the first time. Of salt lakes, the most remarkable is the Dead Sea, from the extraordinary quantity of saline matter contained in its waters, which exceeds in more than sevenfold ratio that found in the waters of the ocean, and from the unparalleled depression below the general level of the earth's surface which its bed exhibits. The water of the Dead Sea has twenty-five per cent. of its weight composed of saline substances, amongst which muriate of soda (common salt) occupies the largest place. No living thing can exist in the intensely salt and bitter water of this lake. The surface of the Dead Sea is upwards of 1300 feet lower than the surface of the Mediterranean. Its greatest depth is 1308 feet, so that the lowest portion of its bed is upwards of 2600 feet below the general level of the earth's surface, which is a greater depression than belongs to the bottom of the Red Sea, even in its deepest portions.

The principal lakes in each division of the globe, classified according as they are salt or fresh, are enumerated in the following tables. The figures in the first column give the area of each lake, in English square miles: those in the second column, its elevation above the sea level, in feet; or, in the instances where the sign minus (—) is affixed, its depression below that level:—

SALT LAKES.

Caspian, (Russia, Persia, Turkestan,)	130,000	—83
Aral, (Russia, Turkestan,)	26,000	31
Balkash, (Russia,)	7000	
Urumiyah, (Persia,)	1800	4300
Van, (Asiatic Turkey,)	1600	5647
Tengri-nor, (Tibet,)	1800	
Koko-nor, (Do.)	1500	
Lop, (Chinese Turkestan,)	1300	

SALT LAKES—*continued.*

Bakhtegaun, (Persia,)	520	
Zurrah, (Afghanistan,)	1600	
Koch-hissar, (Asia Minor,)	570	2850
Dead Sea, (Syria,)	360	—1312
Balaton, or Platten See, (Hungary,)	250	918
Nieusiedler See, (Do.)	150	350
Ielton, (Russia,)	130	
Keroun, (Egypt,)	130	
Assal, (Abyssinia,)	30	—570
Great Salt Lake, (United States,)	1800	4200
Uros, (Bolivia,)	2000	12,357

FRESH-WATER LAKES.

IN AMERICA.

Superior, (United States, Canada,)	32,000	596
Michigan, (United States,)	24,000	578
Huron, (United States, Canada,)	20,000	578
Erie, (Do. Do.)	9600	565
Ontario, (Do. Do.)	6300	232
Champlain, (United States,)	500	
Great Slave, (Hudson Bay Territory,)	12,000	
Great Bear, (Do.)	10,000	
Winnipeg, (Do.)	9000	
Winnipigoos, (Do.)	3000	
Athabasca, (Do.)	3000	
Deer L., (Do.)	2400	
Manitoba, (Do.)	2100	
Wollaston, (Do.)	1900	
Lake of the Woods, (Do.)	1500	
Utah, (United States)	150	4300
Nicaragua, (Central America,)	3500	128
Managua, (Do.)	430	156
Yojoa, (Do.)	150	2050
Chapala, (Mexico,)	1000	

Titicaca, (Peru and Bolivia,)	3800	12,874
Patos, (Brazil,)	5000	

IN ASIA.

Baikal, (Siberia,)	14,800	1793
Tong-ting, (China,)	2000	
Zaisang, (Chinese Turkestan,)	1000	
Poyang, (China,)	800	
Tai-hou, (Do.)	700	
Bouka-nor, (Tibet,)	1000	
Goukcha, or Erivan, (Russian Armenia,)	500	5300
Tiberias, (Syria,)	76	—328
Manasarowar, (Tibet,)	150	15,000
Rakas Tal, (Do.)	120	15,000
Palte, (Do.)		

In Africa.

Chad, (Soudan,)		850
Dibbie, (Do.)		
Tzana, or Dembea, (Abyssinia,)	1400	6270
Nyanza,		3570
Tanganyika,	10,000	1800
N'yassi.		
N'gami, (South Africa,)		2800

In Europe.

Ladoga, (Russia,)	6830	
Onega, (Do.)	3280	
Wener, (Sweden,)	2136	144
Saima, (Russia,)	2000	
Peipous, (Do.)	1250	
Enara, (Do.)	1200	
Wetter, (Sweden,)	840	288
Maelar, (Do.)	760	3
Bieloe, (Russia,)	420	
Ilmen, (Do.)	390	
Mlosen, (Norway,)	300	420
Geneva, (Switzerland,)	240	1230
Constance, (Do.)	228	1299
Garda, (Italy,)	183	320
Maggiore, (Do.)	152	678
Neagh, (Ireland,)	150	48
Neufchatel, (Switzerland,)	115	1437
Lucerne, (Do.)	99	1430
Zurich, (Do.)	76	1332
Corrib, (Ireland,)	68	31
Como, (Italy,)	66	684
Thun, (Switzerland,)	22	1824
Brienz, (Do.)	15	1850
Erne, (Ireland,)	57	150
Derg, (Do.)	46	110
Lomond, (Scotland,)	45	22
Ree, (Ireland,)	41	125
Mask, (Do.)	35	65
Awe, (Scotland,)	25	
Maree, (Do.)	30	
Tay, (Do.)	15	
Windermere, (England,)	11	116
Killarney, (Ireland,)	10	68

VIII.

THE OCEAN.

THE Ocean * covers nearly three-fourths of the surface of the globe. It is one vast and continuous fluid surrounding and insulating the land. The great continental masses which constitute the Old and New Worlds become but vast islands when viewed in reference to the entire surface of the globe.

The waters of the ocean are divided by the land into three great basins, to which the names of Atlantic, Pacific, and Indian, are applied. These divisions are distinctly marked out upon the Map of the World. The Atlantic Ocean lies between the coasts of Europe and Africa upon the one side, and those of America upon the other. The Pacific Ocean divides the western shores of the New World from the eastern coasts of Asia and Australia. The Indian Ocean lies to the southward of the Asiatic continent, and is limited by Africa and Australia in the direction of east and west.

In the extreme north and south, however, towards the direction of either pole, and especially in the southern hemisphere, the waters of the great sea have no such definite natural limits. The names Arctic and Antarctic are commonly given to the polar seas. The Arctic Ocean is enclosed for the most part by the lands which form the northernmost extreme of Europe, Asia, and North America, but between the shores of Greenland and Norway (a distance, under the line of the north polar circle, of nearly 1400 miles) it is open to the expanse of the Atlantic, with which, indeed, it is there continuous. With the Pacific, on the contrary, the Arctic seas are only connected by the channel of Behring Strait, less than 60 miles across. The seas that lie within the northern polar circle must therefore be regarded as belonging to the Atlantic basin, though it is convenient sometimes to employ the term Arctic Ocean. How far these seas may actually extend in

* *Greek*, okeanos.

the direction of the pole is unknown, but they have penetrated to a further distance than the parallel of 80° at two points,—one, to the northward of Spitzbergen, where Parry reached in 1827 the latitude of 82° 40′; the other, beyond the head of Baffin Bay, where Dr Kane passed two successive winters (1853-5) in the latitude of 78° 37′, and obtained some evidence of the existence of an open polar sea to the northward of the 81st parallel.

The seas that lie within the southern polar circle are comparatively unknown. The Antarctic Ocean belongs equally to the three great oceanic basins, the waters of which meet in high southern latitudes. If precise definition be needed, we may say that the meridians of Cape Horn and Cape Agulhas —the respective extremes of America and Africa to the southward—prolonged until they meet the Antarctic circle, mark the theoretical limits of the southern Atlantic, on either hand. A similar line drawn from the extremity of Tasmania southward would serve as the limit, in the same direction, between the Pacific and Indian basins. But such divisions have no place in nature, and the name of Southern Ocean is commonly given to the belt of waters which surround the globe in the higher latitudes of the southern hemisphere. Thus, the sea which washes the southern shores of Australia is commonly spoken of as the Southern Ocean.

The waters of the south polar ocean have not been penetrated to so great a distance in the direction of the pole as those that approach the northern extremity of the earth's axis. In 1841, Sir James Ross traced an extensive line of coast stretching continuously between the parallels of 70° and 78°, and reached the latitude of 78° 4′ S.—the highest yet attained. Some detached portions of land observed elsewhere in high southern latitudes—crossed, in some instances, by the line of the polar circle—have been supposed to form part of an antarctic continent.

I. The Atlantic Ocean extends upwards of 9000 miles in the direction of north and south—taking the lines of the north and south polar circles as marking its limits. Its proportions in the opposite direction, east and west, are greatly inferior. Its widest limits are under the tropic of Cancer, where the shores of the African and American continents are upwards of 5000 miles apart. Both to the northward and southward of that line they gradually make nearer approach.

Under the 40th parallel of north latitude, the breadth of the Atlantic (between Portugal and the shores of the United States) is diminished to less than 3400 miles; between the coasts of Ireland and Labrador, to less than 2000 miles; in the 60th parallel of latitude, (between Norway and the southern extremity of Greenland,) to fewer than 1700 miles. Under the direct line of the equator, the opposite shores of Africa and South America are 4200 miles apart; but the shortest measure between the coasts of Senegambia and Brazil—respectively within a few degrees of the line, on either side—falls considerably below the half of those dimensions, being less than 1800 miles. Thence to the southward the shores of the African and South American continents gradually recede, and in the parallel of the Cape of Good Hope they are nearly 4000 miles apart.

The Atlantic Ocean has, in fact, the form of an immense elongated valley, which winds from north to south, somewhat in the shape of the letter S, like the successive curves in the stream of a river. Between the Arctic Circle and the tropic of Cancer, the direction of its coasts upon either side is from north-east to south-west. Thence to the equator, the direction becomes reversed—or from north-west to south-east. From the easternmost headland of Brazil southward, the shores of the South American continent resume the same direction as that of the coasts upon either side of the North Atlantic within temperate latitudes—that is, from north-east to south-west.

The Atlantic is distinguished above either of the other great oceans by its numerous inland seas, gulfs, bays, and other inlets, and the consequent development of coast-line which its shores exhibit. This feature characterises the Atlantic upon either side of its extensive basin, but is more especially noteworthy in the case of its eastern than its western shores. A like characteristic distinguishes the shores of the Arctic Ocean, which, as we have seen above, belongs strictly to the Atlantic basin.

The strictly inland seas* which belong to the Atlantic Ocean are—the Mediterranean and Black Seas, the Baltic Sea, and Hudson Bay, only the last-named of which is on its western side. But a great number of arms of the sea which penetrate within the land—some of them divided from the open expanse of the

* That is, land-enclosed seas—only connected with the ocean by a narrow channel of entrance.

ocean by islands or outlying portions of the continent—may be enumerated as belonging to either side of the Atlantic shores. Among those on the eastern side, besides the various gulfs that belong to the Baltic and Mediterranean Seas, are the North Sea, the Zuyder Zee, the British Channel, the Bay of Biscay, and the Gulf of Guinea. Upon the western side of the same ocean are Baffin Bay, Hudson Bay, the Gulf of St Lawrence, the Bay of Fundy, the Gulf of Mexico, and the Caribbean Sea. With most of these, again, there are connected other channels and partially land-enclosed seas, as in the instance of the channels leading to the entrance of the Baltic, the "narrow seas" that belong to the British archipelago, and those that divide the numerous islands of the Western Indies.

The result of this configuration of the Atlantic is a vast development of coast-line—surpassing in extent that of either of the other great oceans, and probably superior to them unitedly. The Mediterranean Sea alone, with its gulfs, exhibits a coast-circuit of more than 13,000 miles, and the Baltic (even disregarding the multitude of minor inlets which belong to its shores) has a like circuit of little less than 4000 miles. The British Islands alone comprehend a coast-line of more than 6000 miles, if the almost numberless indentations of the Scotch and Irish shores be taken into account. These facts acquire additional importance amongst the truths of physical geography when regarded in connexion with the circumstances already adverted to—namely, that the longer slopes of the land are everywhere turned towards the Atlantic and Arctic Oceans, and that so great a number of the larger rivers of the globe are discharged into their waters.*

The mainland of the New World—stretching in unbroken continuity through more than 8000 miles in the direction of north and south—limits the Atlantic to the westward. A passage from the Atlantic Ocean into the Pacific was first made by Magellan, whose name is given to the well-known strait (now, however, seldom navigated) which divides the dreary shores of Patagonia from the still less inviting rocks of Tierra del Fuego. Magellan discovered this strait in 1520, and was the first to cross the vast expanse of the Pacific.†

* See pages 16 and 63.

† Magellan lost his life upon one of the islands of the Philippine group, but one of the ships which composed his fleet—the *Vittoria*—returned to Europe by way of the Cape of Good Hope, and thus made the first circumnavigation of the globe.

To find a passage between the two great oceans round the opposite (or northerly) extremity of the American continent has tasked the enterprise of Englishmen during nearly three centuries—from the time of Queen Elizabeth to the present age, which has at length witnessed its accomplishment. This is the famous "North-west passage," in the search for which so many gallant men have adventured their lives, from the times of Frobisher down to those of Franklin and M'Clure. The passage—now proved to exist, and readily traced upon any correct map, by way of Baffin Bay, Barrow Strait, Melville Sound, the Arctic Ocean, and Behring Strait—is, however, useless for the purposes of commercial navigation, owing to the severities of an Arctic climate, and to the perils attendant on the vast quantities of ice which accumulate in these distant regions, and annually obstruct their shores.

II. THE PACIFIC is by much the largest of the oceans, and covers more than a third part of the earth's surface—being, in fact, considerably greater in dimensions than the united area of all the continents and islands of the globe. In the direction of north and south—measuring from Behring Strait to the Antarctic circle—the waters of the Pacific Ocean stretch, unbroken by land, through more than 130 degrees of latitude, or upwards of 9000 miles: from east to west—between the 80th meridian west, and the 104th east, of Greenwich—its proportions are still greater, exceeding 170 equatorial degrees, or above 12,000 miles. An ocean that measures twelve thousand linear miles in one direction, and nine thousand in another, must of necessity exercise a vast influence over all lesser features of the earth's surface, and is of the highest importance to mankind.

It is under the line of the equator that the Pacific attains its widest limits. Thence, both in the direction of north and south, its opposite shores gradually approximate. Under the line of the northern tropic they are separated by 136° of longitude, and by rather more than that distance along the line of the southern tropic. To the northward of the Tropic of Cancer, the coasts of North America and Asia make rapid approach towards one another, and at Behring Strait they are divided by less than 60 miles. The Pacific exhibits, in fact, the shape of an immense oval, the largest diameter of which coincides with the line of the equator. But the circumference of this oval is imperfect to the southward, where the waters of the vast ocean

stretch—uninterrupted by land—to the line of the Antarctic circle, perhaps to the pole itself.

The circuit of the Pacific exhibits no true inland seas, such as those that belong to the Atlantic basin. Nor do its eastern shores display, except in the instance of the Gulf of California, any indentations of a magnitude comparable to those that belong to the correspondent portion of the Atlantic sea-board. But the western shores of the Pacific exhibit a feature peculiarly characteristic of this ocean, in the range of seas and gulfs which are found between the mainland and the neighbouring groups of islands. Among them, proceeding from north to south, are the Sea of Kamschatka, the Sea of Okotsk, the Japan Sea, the Yellow Sea, the East Sea (of China,) and the China Sea, with their numerous smaller gulfs and channels. These are not inland seas, like the Mediterranean or the Baltic. They are merely extensions of the ocean itself, partially divided from its main body by a succession of island-groups. Between these islands there are numerous channels, which connect the partially land-locked gulfs of the Pacific with the ocean itself, and also with one another.

The Pacific Ocean is likewise distinguished by the numerous coral and other islands—for the most part of exceedingly minute proportions—scattered over its vast expanse. These, which form the division of the globe known in modern geography as Polynesia, are elsewhere referred to.

III. The Indian Ocean is much smaller than the Pacific or Atlantic, and has a marked feature of distinction from either of those oceans in the fact of its being limited by land to the northward. The waters of the two other great oceans stretch to the confines of the frigid zone, in either direction, north and south alike. The Indian Ocean is bounded on the north by the continent of Asia, and is only open in the direction of the Antarctic circle. Important consequences in regard to the climate, and other conditions in the physical geography of the lands that lie around its shores, ensue from this fact.

Under the equator, the Indian Ocean measures little less than four thousand miles across. Further south, along the tropic of Capricorn, the breadth is increased to upwards of five thousand miles.

The Indian Ocean has two inland seas,—the Red Sea and

the Persian Gulf. These are of much smaller dimensions than the inland seas which belong to the Atlantic basin. The Red Sea has an area of 180,000 square miles, and is connected with the ocean by a single channel of entrance—the Strait of Bab-el-Mandeb, sixteen miles across. The Persian Gulf, about 95,000 square miles in area, is entered by the Strait of Ormuz, which has a breadth of 40 miles. The Gulf of Aden, the Gulfs of Cutch and Cambay, the Bay of Bengal, and the Gulf of Martaban, are offsets of the Indian Ocean, but are neither inland seas nor land-enclosed gulfs.

The waters of the Indian Ocean are connected with those of the Pacific by the channels which divide the innumerable islands of the East Indian Archipelago. The Strait of Malacca and the Strait of Sunda are the two most important of these passages. They lead directly from the Indian Ocean into the China Sea, and are annually navigated by a vast number of vessels of every class, engaged in the extensive traffic which belongs to the shores of that richly-diversified portion of the globe. Singapore, at the southern extremity of the Malay peninsula, and Batavia, on the northern coast of Java, are the emporiums of European commerce in this region, and have been called into existence by the energies of the British and Dutch traders thither.

Under a more eastwardly meridian, the broader passage of Torres Strait—so called from its discoverer, a Spanish navigator of the seventeenth century *—forms an important channel of connexion between the Indian and Pacific Oceans. But the coral reefs with which it is beset render it perilous to the navigator. The "Great Barrier Reef" of coral, which lies beyond, stretches for above a thousand miles along the eastern sea-board of the Australian continent, and the mariner threads his way with difficulty through its narrow and intricate passages. At the opposite extremity of the Australian shores is the channel which derives its name from Mr Bass, of the English navy, by whom it was discovered in 1797. Bass Strait unites the waters of the Pacific with those of the Southern Ocean.

Every circumstance connected with the great ocean—its varying depths, the temperature of its waters, their chemical

* Luis vas Torres, who held the second place in rank in the expedition o -os, in 1606.

properties, movements, and other phenomena, with the forms of life of which they are the seat—constitutes a topic of interest to the physical geographer, and has formed a subject of scientific inquiry. The physical geography of the sea forms, indeed, a necessary supplement to the physical geography of the land, and it is only by a combined study of the two that we can attain an adequate conception of the natural condition of the globe's surface, and of its varied influences upon the destinies of man.

DEPTH.—The depth of the sea has formed within recent years a subject of earnest inquiry. The practical requirements of the navigator have at all times made it necessary to know the depth of water at the mouths of rivers, the entrances of harbours, and in the immediate neighbourhood of shores frequented by shipping. Hence the elaborate charts that are issued by the boards of Admiralty of our own and other nations, and upon which are marked the results of detailed surveys in which the sounding-line has been the most important instrument of observation. In shallow seas, such as the German Ocean or the Baltic, where numerous sand-banks rise above the general level of the bottom, and in many cases even reach the surface at low water, a knowledge of the exact depths is indispensable to the mariner. The sounding-line and the chart furnish the only safe means by which he can guide his vessel through their waters. This is more particularly the case during the frequent prevalence of dense fogs, by which these and other parts of the ocean—the Gulf of St Lawrence, for example—are often covered. The agency of violent storms, and the yet more powerful action of currents, produce frequent changes in the sand-banks deposited upon the ocean's bed, and necessitate the frequent renewal of observations on their extent, with the depth of intervening channels, and other conditions.

The attainment of deep-sea soundings has within a recent period assumed an equally practical character, in connexion with the laying of submarine cables to connect the telegraphic stations now so generally distributed over the land. The narrow seas which divide Britain from the shores of the continent, the waters of the Mediterranean, the Red Sea, and the adjoining portions of the Indian Ocean, are already crossed by the wires of the submarine telegraph, and even the bed of the Atlantic has been similarly traversed. Such achievements,

be made with any fair prospect of tangible result, require the possession of a vast number of observations upon the depth and character of the ocean's bed along the proposed line of route.

Further, a knowledge of the bed of the sea is necessary to the possession of a true idea of the physical geography of the globe. The reliefs of the land are continued below the surface of the waters. The mountain-chain—invisible for a time where its slopes sink below the Atlantic or the Pacific waves—reappears in the island-groups of the deep. A knowledge of the constituent particles which are drawn up, by the aid of the sounding-line, from the bottom of the sea, supplies the scientific observer with information of high value as to direction of currents and other conditions of the aqueous portion of the globe, and reveals, besides, much that is of interest in connexion with the geological changes which our planet has in former ages undergone, and the forms of life of which it has, at some former epoch, been the seat.

Such observations show that the bed of the sea possesses inequalities correspondent to those that diversify the surface of the land, and probably on a scale of more considerable magnitude. The sea has its plateaus and lowland-plains—its mountains and valleys—its deep depressions and precipitous slopes—like the surface of either continent. The British Islands rise from a moderately-elevated submarine plateau, the soundings for some distance immediately around their shores nowhere exceeding a hundred fathoms. About fifty miles to the westward of the Scotch and Irish coasts, the depth rapidly passes from one to above two hundred fathoms, and thence gradually increases, until at a distance of about 180 miles to the west of Ireland, (in lat. 15° W.,) the sounding-line suddenly sinks from 550 to 1750 fathoms—showing a depression of twelve hundred fathoms—a wall or precipice in the bed of the ocean. It is here that the deep basin of the Atlantic really commences.

Again, along the eastern coast-line of Britain the land, for the most part, shelves gradually down into the water, like a plane inclined at a moderate slope; and it is only at a considerable distance from the land that any great depth is attained. The same thing occurs in the instances of the Dutch and Flemish coasts. But the mountains of the Scandinavian peninsula rise abruptly out of the waters of a deep sea, and the numerous *fiords* which indent the shores of Norway carry

the waters of a deep (and, in popular language, a fathomless) sea into the heart of the mountain-region.

The Mediterranean exhibits instances of depth, which, considered with reference to the comparatively moderate distances between its opposite shores, are very striking. The Mediterranean is a deep sea throughout, with the sole exception of a narrow ridge which forms a submarine connexion between the shores of Africa and Sicily, and above which the depth of water varies between 50 and 500 fathoms. This ridge divides it into a western and an eastern basin, both of which are very deep. In the former, a maximum depth of 1600 fathoms has been found between the coasts of Spain and the island of Sardinia; in the eastern half of the same sea, a depth of 2170 fathoms (above 13,000 feet, or nearly two and a half miles) has been reached by the sounding-line between the islands of Malta and Candia, while 1600 fathoms is stated as the maximum depth in a line of soundings taken between the island of Rhodes and the Egyptian coast. The maximum depths of the great inland sea thus appear to correspond to the extreme altitude above its surface which is reached by the mountain-chains that enclose its waters, while the average depth of its bed is perhaps equivalent to the mean height of the plateaus which adjoin those mountains towards the interior—as in the instances of the Spanish plateau, the table-lands of southern Germany, and those which occupy the interior of the Lesser Asia. The Strait of Gibraltar has an extreme depth of 980 fathoms.

The greatest ascertained depth of the Red Sea is 1050 fathoms; that of the Baltic not more than 140 fathoms. In the Caribbean Sea, depths exceeding 2300 fathoms have been ascertained; in the Gulf of Mexico, above 1300 fathoms. The greatest depths hitherto ascertained in the Indian Ocean are 2254 fathoms, (5° 30′ S. lat., 61° 40′ E. lon.).

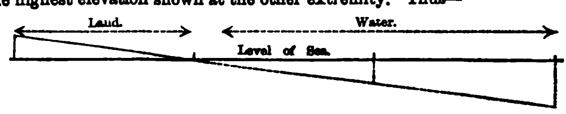
All the above instances, however, fall far short of the depths ascertained to exist in parts of the open ocean, away from land, and in the midst of the great waters. In the northern half of the Atlantic basin, a maximum depth of 25,000 feet has been found by the officers of the American navy. This occurs between the parallels of 35° and 40° north latitude, to the southward of the great Banks of Newfoundland. Still greater depths have been ascertained in the southern Atlantic. In 1843, Sir James Ross found, to the westward of St Helena, a depth exceeding 27,000 feet; and, in

1852, another officer of the English navy, Captain Denham, reached bottom at the astonishing depth of 46,236 feet, S. lat. 36° 49′, W. lon. 36° 9′.

It is possible that the extreme depths here indicated may (owing to errors of observation, dependent chiefly on the drift of the waters, and the consequent difficulty of preserving the vertical direction of the sounding-line) be somewhat in excess of the truth. But they are in strict accordance with theory. It may be assumed that the greatest depths *below* the ocean's surface are at least as great as the maximum altitude *above* the same datum. The extreme ascertained depth of the north Atlantic falls considerably below the culminating points of the Himalaya, but is a little in excess of the extreme elevation of the cordilleras of the New World. The depression of the south Atlantic, ascertained by Sir James Ross, more nearly coincides with the altitude of the Himalaya above the sea level. The still greater depth indicated in Captain Denham's observations, (equivalent to eight miles and three-quarters,) though vastly in excess of the highest elevations of the land, yet does not surpass them in greater measure than the ratio in which the whole superficial extent of the water exceeds the area of the land.*

The *temperature* of the sea undergoes much less variation than that of the land. It generally falls with the increase of depth, in warm and cold latitudes alike, and observations appear to render it highly probable that at very considerable depths a nearly uniform temperature, and *that* a very low one, is everywhere maintained. While the surface-temperature of the Caribbean Sea, in the month of September, showed 83°

* The water covers considerably more than two-thirds of the earth's surface. If we divide the whole superficial area of the globe—assumed to be represented by a straight line—into three equal parts, and then, supposing an inclined plane to indicate the average slope of the entire land area, from its culminating point downwards, prolong this plane below the surface, we find, of course, at the one extremity of the line a maximum depth which exactly doubles the highest elevation shown at the other extremity. Thus—



It is true that neither land nor water are continuous through spaces equivalent to the divisions marked on such a line. But the Pacific Ocean alone covers half the area of the globe, and there is nothing forced in the supposition that its greatest depths may be found vastly to exceed any of the observations yet made on this head.

of Fahrenheit, the water at two hundred and forty fathoms was only 48°, and at five hundred fathoms only 43°. According to Maury, the temperature at correspondent depths off the shores of Spitzbergen, within the Arctic Circle, is only one degree colder than that of the Caribbean Sea. At any rate, in both localities, whatever the surface-temperature, it continually decreases with increase of depth. Scoresby relates that on the coast of Greenland, in lat. 72°, the temperature of the air was 42°, of the surface water 34°, and at the depth of a hundred and eighteen fathoms only 29°.

The surface-temperature of the waters, in every parallel, perhaps nearly corresponds to the *mean* temperature of the air in that latitude. But currents, which carry the warm waters of one zone of the globe to colder regions, or the reverse, must largely modify this general law. At the bottom of the Gulf Stream, when its surface-temperature was 80°, the deep-sea thermometer has recorded a temperature as low as 35°.*

The most important truth concerning the temperature of the sea, however, is the fact of the little change which it undergoes throughout the year, as compared with the land. It is to this that its most important influences upon climate are due, as we shall see in a future page. Between the hottest hour of the day, and the coldest hour of the night, the maximum difference in the temperature of the sea does not exceed four degrees.

The *saltness* of sea water constitutes one of its well-known characteristics. This, as well as its intense bitterness, and great specific gravity, is due to its holding in solution various saline particles, amongst which muriate of soda—that is, common salt—holds the most important place.†

The proportion of saline matter which the sea contains is not uniformly the same. The saline contents of the open ocean average in general from 3·5 to 4 parts in every hundred, estimated by weight. That is, in any given weight of water, a proportion of three and a half or four per cent. is composed

* Maury: Physical Geography of the Sea.

† The following analysis of sea water, made by Dr Murray, is quoted by Dr Traill. Ten thousand parts of the water were found to contain:—

Muriate of soda	245·04
Muriate of magnesia	28·63
Sulphate of magnesia	17·04
Sulphate of soda	2·66
Sulphate of lime	9·72
	303·09

of saline matter, which, by evaporation, becomes a solid residuum of salt. Hence the facility with which salt is obtained at many places on the sea-coast, where extensive *salines* are formed (as upon the shores of Portugal, and on various parts of the Mediterranean coast) for the purpose of evaporation by the hot rays of a summer sun.

The waters of the Gulf Stream, which cover an immense area of the North Atlantic, are distinguished from other parts of the ocean by their greater saltness and their deeper blue; the greater intensity of colour being a consequence of the larger proportion of briny matter held in solution. The difference in quantity between the saline contents of the Bay of Biscay, and the waters of the Gulf Stream off Charleston, in the United States, amounts to a half per cent., and the difference is still greater in the case of other portions of the same current. Near the mouths of rivers, the saltness of the sea becomes lessened by the quantity of fresh water poured in. The current of the Amazon and the La Plata may be traced at a distance of several hundred miles away from land.

The waters of the Mediterranean contain more salt than those of the ocean, the proportion of saline matter contained in them being fully five per cent. of their weight. The Red Sea offers a like instance of superior abundance of saline matter in its water. The Baltic, on the other hand, is less salt than the ocean, and its gulfs become, towards their upper extremities, almost fresh. The number of large rivers which discharge into the Baltic, together with the outward current through the straits by which it is connected with the open sea, sufficiently account for the last-named fact. In the Mediterranean, on the contrary, the volume of fresh water poured in by rivers bears but a trifling proportion to the area of its vast basin. The Nile is the only river of first-rate magnitude which discharges into it. Further, a current constantly sets into the Mediterranean through the Strait of Gibraltar. This current is constantly carrying the salt water of the Atlantic into the Mediterranean basin. Evaporation furnishes the chief (if not sole) means by which this constant influx of water is carried off, and the general equilibrium of its contents preserved. But evaporation only carries off fresh water, leaving behind the saline particles of the ocean's contents. It is, therefore, highly probable that the saltness of the Mediterranean may be slowly on the increase. The

Red Sea offers a still more striking instance of like kind, since it does not receive a single perennial stream, while its loss from evaporation is supplied by a constant current flowing in through the Strait of Bab-el-Mandeb.

There is no proof that the saline contents of the ocean undergo, on the whole, any change in their proportion. It is undoubtedly true that all so-called fresh waters contain a small quantity of the same saline particles that are found in the sea-water. The influx of rivers, and the washings occasioned by rain-fall upon the land, thus alone furnish a sufficient explanation of the present saltness of the ocean. But although evaporation fails to carry off the continual accumulation of saline matter thus supplied to the ocean, yet there are other natural agencies at work, such as the secretions of marine insects and other inhabitants of the ocean, which preserve the general balance unaltered.

The specific gravity of sea-water, compared with fresh water at 1, amounts to a mean of 1·026. Some observations appear to show a slightly higher specific gravity in the water of the Atlantic than in that of the Pacific Ocean. In the case of both, the specific gravity becomes lessened near the mouths of large rivers, owing to the influx of fresh water. The specific gravity of the Mediterranean is greater than that of the ocean, a result due to the larger proportion of saline ingredients in its waters.

The *colour* of the sea is well known, at least by observation in the immediate neighbourhood of the land. But the pale sea-green tint which distinguishes shallow waters assumes a bluer shade with increasing depth, and far away from land, in the midst of the great ocean, becomes a deep indigo. This deeper shade of blue is connected with the increased saltness, as well as depth. The waters of the Gulf Stream, off the coast of Carolina, are of a deep indigo hue, and are readily distinguishable by colour alone from the water amidst which they flow. The Mediterranean is celebrated for the intense blue of its water. The Red Sea, notwithstanding its name, possesses a like distinction in the deeper portions of its mid-channel. It is only amidst the coral-reefs which border its shores on either side, that the reddish hue of its water, due to abundance of microscopic animal life, is observable.

Local peculiarities in the colour of the sea are due to various causes. The muddy sediment carried down by the great rivers of the Chinese plain explains the prevailing t-

which gives its name to the Yellow Sea. The alternate streaks of blue and green, which have been observed in the Greenland Seas and elsewhere, are due to abundance of minute forms of animal life.

CURRENTS.—The sea is seldom in a state of perfect rest. The winds, for the most part, maintain the surface of the water in constant motion, and the agency of the tides occasion a continual change in their level. But besides these causes of disturbance, there are streams in the ocean, equivalent to rivers on the land, but on a scale of vastly greater magnitude. These ocean-rivers are known as *currents*, and a knowledge of their direction, rate of flow, and other conditions, is of the highest importance to the navigator.

It is not difficult to account for the existence of currents in the sea. The mobile nature of water causes it to yield to every pressure. Whatever disturbs the equilibrium of the whole fluid mass occasions a transference of its particles from one place to another, and if the disturbing influence be constant, a constant motion of the waters is the necessary result. If two fluids, or two portions of the same fluid, possessing different densities, be placed in contact, a movement of their particles is at once engendered. The denser portions sink towards the bottom, and form the lower strata of the whole, while the lighter portions rise to the surface. The mingling of oil and water in one vessel serves to illustrate this. Now the sea is not of uniform density. Water becomes heavier in proportion as it is colder. The warm water of intra-tropical latitudes is specifically lighter than the cooler water of temperate regions, and that again possesses less density than the colder water of the Arctic Seas. These differences are constant, for the cause by which they are occasioned, the varying amount of solar heat, is in continual operation. Hence the movements which they occasion in the water are constant also. The colder water of polar latitudes has a tendency to distribute itself over the lower strata of the ocean, while the warmer water of equatorial latitudes seeks to diffuse itself over the surface. A flow and re-flow in the waters of the ocean, regarded as a whole, is thus engendered: currents of warm water in a direction from the equator towards the poles, and currents of cold water in the

opposite direction, being the result. Various causes operate in modifying this normal direction, one of the most obvious of them being the shape of the land, which necessarily gives a partial direction to the streams that wash its coast, while it is also in some degree a consequence of the existence of such agencies. The particular form and depth of the ocean's bed affect similarly the direction of deep-sea currents, and, like the shape of the visible land, are to be regarded at once in the light of causes and consequences.

The varying extent to which evaporation takes place in different latitudes is another explaining cause of ocean-streams, or currents. Its tendency is to set the waters of high latitudes in motion towards the warmer regions of the globe, in order to supply the waste occasioned by excessive evaporation thence. Polar currents continually carry the cold water of Arctic and Antarctic seas towards the warm belt of the tropics, there to be converted, under the burning rays of a vertical sun, into the masses of vapour which are afterwards carried by the wind over neighbouring lands, and returned to the earth in copious floods of rain. We see the operation of this cause in the floating ice which currents, flowing from the direction of the Arctic and Antarctic poles, continually bring into the zones of temperate water.

A condition of nature which importantly affects currents is found in the earth's diurnal rotation—that is, its motion on its axis in a direction from west to east. It is the more important to understand this, because it affects the currents of the atmosphere (or winds) in precisely the same manner that it does the currents of the ocean. The earth's axial rotation is not of itself a cause of either currents or winds, for land, sea, and air, all have the same eastwardly motion. But a transfer of either sea or atmosphere from one part of the globe to another part where the axial motion is either more or less rapid, must of necessity result in a modification of the normal motion which such transferred portion of sea or air previously possessed. A little reflection serves to explain this. The earth makes one complete rotation on its axis in twenty-four hours. At the equator, the earth is twenty-four thousand miles round, and any given spot in that line is therefore continually moving in an eastwardly direction at the rate of a thousand miles an hour. But with every successive degree of removal from the equator towards either pole, the circles which measure the earth's circuit are progressiv

smaller. The rate of axial motion under every successive circle becomes therefore progressively less, for the smaller circle only makes a single rotation within the same period of time as the larger circle—that is, twenty-four hours. Thus, under the 60th parallel of latitude, the measure of the earth's circuit is only 12,000 miles, or half the circuit of the equator. Any spot in the latitude of 60° has hence an axial motion equivalent only to five hundred miles an hour—or half the rate of motion proper to a place under the equator. At the poles—the extremities of the earth's axis —the axial motion has no existence.

Now, suppose a current—by whatever cause engendered—to be set in motion from the neighbourhood of the pole towards the equator. This current, were the earth at rest, would travel along the line of a meridian—that is, it would move from north to south, if in the northern hemisphere, and from south to north, if in the southern half of the globe. But instead of being at rest, the earth is moving on its axis, and the current necessarily shares in this axial motion. Under whatever parallel we may suppose the current to originate, there is a given rate of speed proper to the axial motion of that parallel. But in travelling towards the equator, the current is advancing into regions of *continually increasing rate of axial motion*, and, unable at once to acquire this more rapid rate of eastwardly rotation, it constantly lags behind the general motion of the regions towards which it is moving, and acquires hence some amount of westwardly direction, while still preserving its general advance towards the equator. In other words, its actual motion, instead of being along the meridian, is a resultant of the two directing forces. If in the northern hemisphere, it acquires a motion from the north-east (instead of from due north)—that is, it becomes a south-west current. If in the southern hemisphere, its actual motion is from the south-east, (instead of from due south,) and it becomes a south-east current.

Suppose the contrary case, of a current setting out from the neighhourhood of the equator towards either pole. Disregarding the earth's axial motion, such a current would have, in the northern hemisphere, a direction from south to north: in the southern hemisphere, a direction from north to south. But in this case, the advance of the stream is from regions of quicker axial motion into regions of diminishing eastwardly motion. The advancing current, preserving for a time its

superior rate of eastwardly motion, (proper to the latitudes of its origin, and only gradually lost in its onward course,) gets continually in advance of the axial motion proper to higher parallels—or, in other words, it acquires a resultant motion which is to the eastward of the meridian. Hence, in the northern hemisphere, a current which, if the earth were at rest, would travel from south to north, acquires a motion to the east of north—that is, it becomes a north-eastwardly current. In the southern hemisphere, a like stream, acquiring a similar motion to the eastward, becomes a south-eastwardly instead of a due southwardly current.

The three following causes, then, account for the existence of ocean-streams, or currents, and explain their *general* direction :—

1. Difference of temperature, and consequently of density, in the waters of the ocean.
2. Excessive evaporation in the warmer latitudes of the earth, as compared with its more temperate latitudes.
3. The earth's rotation on its axis, which modifies the normal direction of the streams engendered by the two preceding causes.

The whole ocean exhibits, in truth, a great system of currents, which are more or less connected with one another, and form parts of a vast whole. Every current is of necessity accompanied by a counter-current, and the continual flow and re-flow of the waters preserve equilibrium in the distribution of the whole fluid mass. Navigators distinguish between *drift-currents* and *deep-sea currents*—the former being due principally to the constant agency of the wind, blowing for a length of time (or, as is the case in certain parts of the globe, blowing continually) in the same direction. The drift-current affects merely the surface of the water—or, at any rate, is not felt at more than a trifling depth. But the deep-sea current, due to the causes explained above, extends its influence down to many hundreds of fathoms.

I. The Atlantic Ocean.—The principal currents of the Atlantic are :—

1. The Gulf Stream, which has a general course *to the eastward*, or, more precisely, from south-west to north-east.
2. The Arctic or Greenland Current, setting *from north to south*.
3. The Equatorial Current, *from east to west*.
4. The Brazilian Current, a branch of the preceding, setting along the coast of Brazil, *to the south-westward*.
5. The Guinea Current, setting *from north to south*, along the western coast of Africa, to the northward of the equator.

1. The Gulf Stream is the most important and powerful of currents. Its name is derived from the fact of its origin in the Gulf of Mexico, whence it issues by the narrow channel of Florida. Its course is thence to the north-eastward, parallel to the shores of the United States. About Cape Hatteras (lat. 35° 13′) it strikes off more to the eastward, and off the Great Banks of Newfoundland becomes nearly due east. It then crosses the Atlantic Ocean in the direction of the European continent, gradually becoming more and more mingled with the general waters of the ocean as it approaches the neighbourhood of the Azores.

The Gulf Stream is throughout distinguished by its superior warmth, compared with the temperature of the adjacent ocean. The difference amounts to 20°, and sometimes even to as much as 30°. The Gulf Stream is, in fact, a vast river of warm water, flowing between banks of cooler water upon either hand. The velocity of the current is greatest in the commencing or narrower portion of its course, and gradually diminishes as its volume of water spreads out to wider dimensions. As far out from the Gulf of Mexico as the coasts of Carolina, the water of the current is of an indigo hue, and is readily distinguishable in appearance from the common sea-water, which is of a pale green.

The tendency of the Gulf Stream, regarded as an agent of influence upon climate, is to carry the superior temperature of its water to the vicinity of those parts of the globe towards which its course is directed, that is, towards the shores of Western Europe. The winds which approach Europe from the south-westward bring with them the higher temperature, as well as the moisture, derived from those portions of the great ocean over which they have passed.

2. The Arctic or Greenland Current is a stream of cold water, and produces effects upon climate precisely the reverse of those that ensue from the Gulf Stream. It flows along the coasts of Labrador and Newfoundland, with a southwardly course, and brings down the cold water and the vast floating icebergs of Baffin Bay into the western parts of the Atlantic. The influence of the Arctic Current is perceptible as far south as the latitude of 40°; along the north-easterly portion of the United States seaboard the cold-water current from Baffin Bay, and the warm current of the Gulf Stream, flow side by side, parallel to one another, but preserving opposite directions, and without mingling their waters.

3. The Equatorial Current of the Atlantic crosses the ocean from east to west, in the immediate neighbourhood of the equator—that is, it flows from the coasts of western (or rather south-western) Africa towards those of South America. On approaching the latter, a branch known as the Brazilian current leaves the main stream, and flows in a south-westwardly direction along the shores of Brazil.

II. THE INDIAN OCEAN.—The principal currents of the Indian Ocean are :—

1. The Equatorial Current, from east to west.
2. The Agulhas Current.

1. The Equatorial Current of this ocean consists in a general flow of its tropical waters to the westward. Towards the neighbourhood of the African coasts, the land deflects the stream in a southwardly direction, parallel to the shores of Eastern Africa.

2. The Agulhas Current is so called from Cape Agulhas, the southernmost extremity of Africa. It originates in the Indian Ocean, and is (in its origin) an extension of the equatorial current of that sea. Two streams which flow upon opposite sides of the island of Madagascar unite, and the current thence sets round Cape Agulhas, to the westward—that is, from the Indian into the Atlantic Ocean. The Agulhas banks, however, deflect a portion of the stream, and form a returning current, which re-enters the Indian Ocean in a more southwardly latitude, and has a course to the eastward.

tween the parallels of 36° and 40°. It is this eastwardly current, experienced within the higher latitudes of the Indian Ocean, which (conjointly with winds which blow in the same direction) facilitates the outward passage of ships bound from Europe to Australia, by way of the Cape of Good Hope.

III. The Pacific Ocean.—The principal currents of the Pacific Ocean are :—

1. The Equatorial Current, *from east to west.*
2. The Antarctic Current, which consists in a general drift of the waters of the South Pacific, in high latitudes, *to the northward*—that is, toward the direction of the equator.
3. The Peruvian Current, *from south to north.*
4. The Cape Horn Current, setting round the southern extremity of the New World, *to the eastward*—that is, from the Pacific into the Atlantic.
5. The Japanese (or China) Current, from *west to east.*
6. The Mexican Current, which flows along the coasts of Mexico and Central America, its direction varying with the change from winter to summer, or the reverse. During the former season, its course is to the south-eastward : during the opposite half of the year, this direction is reversed, and the current sets to the north-west.

1. The waters of the Pacific, in the neighbourhood of the equator, like those of the Atlantic and Indian Oceans, have a general flow to the westward.

3, 4. Both the Peruvian and the Cape Horn Currents appear to be extensions of the Antarctic Current. The former has a low temperature, comparatively to the adjacent ocean. It flows along the coasts of Chili and Peru, in a northwardly direction, and maintains its lower temperature nearly as far north as the equator.

5. The Japanese or China Current has been supposed to correspond, in the northern Pacific, to the Gulf Stream of the North Atlantic Ocean. Very much less is known about it, however, than is known of the latter stream. The current sets to the eastward, past the shores of Japan, and thence


OCEAN-CURRENTS.
The Arrows show the Direction of the Currents.
Arctic Circle
Equatorial Current
Japanese Current
Tropic
Equator
Antarctic Current
Mexican Current
Gulf Stream
Sargasso Sea
Brazil Current

appears to cross the ocean in an eastwardly direction. The Japanese are said to be well aware of its existence, and to have given it the name of "Kuro-Siwo," or Black Stream,* —an appellation in all probability derived from the deep-blue colour of its water, when compared with that of the adjacent ocean. In this characteristic, the probable result of its greater abundance of saline matter, as well as in other regards, this current resembles the Gulf Stream of the North Atlantic. Like that stream, too, the current of the North Pacific carries with it across the ocean pieces of timber and other transportable material, to be cast upon the shores of the distant lands towards which its course is directed. "The natives of the Aleutian Islands, where no trees grow, depend upon the drift-wood cast ashore there for all the timber used in the construction of their boats, fishing-tackle, and household gear. Among this timber, the camphor-tree, and other woods of China and Japan, are said to be often recognised." †

A current sets through Behring Strait, from the Pacific into the Arctic Ocean.

Regarding the ocean as a whole, it is obvious that all its movements are, in greater or less degree, connected with one another. The currents of one ocean, in most cases, if not in every instance, are continuous with those of the other oceans. The general direction of the waters, within tropical latitudes, is *to the westward:* within temperate latitudes, the direction is the reverse, or *to the eastward.* In the higher latitudes, the direction, in either hemisphere, is *from the pole towards the equator.*

The Mediterranean Sea has a constant current setting into it from the Atlantic, through the Strait of Gibraltar. The water thus continually added to its contents is carried off by evaporation from its surface. A current from the Black Sea also passes into the Mediterranean through the Channel of Constantinople and the Dardanelles.

TIDES.—The explanation of the tides is astronomical. They are caused by the attraction which the moon exerts over the

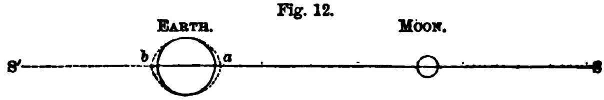
* Lieutenant Bent, of the U. S. Navy, quoted in Maury's "Physical Geography of the Sea."

† Ibid.

waters of the earth. The sun exerts a like attractive influence, but in a much less degree than the moon, owing to its vastly greater distance.

The attraction exercised by the sun and moon over the waters of the earth is a consequence of the law of universal gravitation. This law is embodied in the axiom that "every particle in the universe attracts every other particle, with a force which bears an inverse ratio to the square of the distance"—that is, a force which increases as the square of the distance is diminished. The moon is the nearest of the heavenly bodies to the earth, and the mobile nature of water leads it to yield readily to the attractive influence. Those parts of the waters which are nearest to the moon—that is, the parts directly under the moon's vertical path in the heavens—are hence drawn out towards the moon. From precisely the same cause, and at the same time, the waters farthest away from the moon—or at the opposite side of the earth—are led to bulge out beyond the general line of the globe's circumference. The subjoined diagram shows the figure which the waters of the earth thus assume under the moon's attraction:—

Fig. 12.



The waters at *a* are drawn out towards the moon, because that portion of the earth's surface is nearer than any other part. For the same reason, the waters at *b*, being farthest away, experience the gravitating force in the least degree, and recede farther from the attracting body than any others. The waters of the globe, therefore, culminate at the same time toward those points which are under the moon's vertical influence upon opposite sides of the earth. In doing this, they are drawn away from those parts of the globe which are 90° distant from this vertical influence—that is, from the meridians which are farthest removed from the meridian over which the moon is at any given moment vertical.

The tidal changes, considered as a whole, are a result of the above conditions. It is high water at the same time upon opposite sides of the meridian over which the moon's path is situated, and low water under meridians which are 90° distant upon either side.

The earth's rotation on its axis occasions an apparent circuit of the moon (with all the heavenly bodies) round the earth, in a direction from east to west. Every place on the earth is thus brought in succession under the direct line of the lunar influence, and passes thence to the points which are farthest removed from that influence. The conditions of high and low water hence recur twice within each successive period of the moon's return to the same meridian—that is, within twenty-four hours and fifty minutes.

The period of the moon's return to any given meridian, after accomplishing an apparent circuit of the globe, is greater by fifty minutes than the mean solar day (24 hours), owing to the fact of the moon's monthly circuit round the earth, performed in the same direction as the motion of the earth on its axis—that is, to the eastward. While the earth accomplishes one revolution on its axis, the moon is advancing in her orbit. The earth has hence to make rather more than a complete rotation in order to arrive at the same position, relatively to the moon, that it had on the preceding day. In other words, it takes a little more than twenty-four hours for the moon to return to its vertical place over any given meridian. Hence the interval between the successive conditions of high and low water is a little in excess of six hours, and the high and low water of any given day are later by nearly an hour than they were on the preceding day.

The sun's influence upon the tides is evidenced in its either increasing or diminishing the lunar tide, according as the sun's place in the heavens coincides with the line of the moon's attraction, or the reverse. A reference to the diagram in page 103 will explain this. When the Sun, relatively to the Moon and Earth, is in either one or other of the places marked S, or S′, its gravitating force acts upon the waters of the earth in the same direction as that exerted by the Moon. The solar influence, in either case, is added to the lunar influence, and the tidal wave which is generated is higher than would be the case under the influence of the Moon alone. In the former case,—that is, supposing the Sun at S,—the darkened side of the Moon is toward the Earth, and it is new moon. In the latter, the Sun being at S′, the Moon's enlightened half is directed to the Earth, and it is full moon. When, on the other hand, the place of the Moon in the heavens is 90° distant from the Sun's place,—which is the case when the Moon is either seven days or twenty-one days old, that is, in either

her first or her last quarter,—the Sun's influence over the Earth's waters acts in a contrary direction to the lunar influence, and tends to diminish the height of the lunar tide. It is this difference which produces what are known as Spring tides, and Neap tides. The former occur at the times of new and full Moon, and are the added result of the gravitating influence of both Sun and Moon: the latter occur when the Moon is in her quarters, and are not so high as the spring tides, because they exhibit the lunar influence lessened by the Sun's force acting in an opposite direction.

Such is the general theory of the Tides, but the actual time of high water at any place, and the height of tide (or difference of level between high and low water) depend upon various local conditions. It is within the unbroken expanse of the Southern Ocean—where alone the waters of a deep sea extend continuously round the entire circuit of the globe—that the tidal wave is generated; and its course thence towards other parts of the sea is determined in great measure by the particular shape of the enclosing land, and the direction of the coasts, as well as the depth of the sea and the nature of its bed. Thus, the tide which is experienced at any place must be regarded, not as having its origin in that particular locality, but as derived from the great tidal wave which has been generated in a far distant latitude. The tidal wave which washes the shores of Britain comes from the south-west. On approaching the British shores, it divides,—one branch setting up the English Channel, while another passes up the sea which divides Great Britain and Ireland, and a third branch passes to the westward of Ireland. The wave which passes to the west of the Irish and Scotch coasts afterwards sets to the east and south-east, flowing down the eastern coasts of Britain, and meeting, off the south-eastern coasts of England, the tidal waters which have reached the same point by the shorter course up the Channel. The precise time of high water at any given place presents, therefore, a problem which is complicated by many conditions.

Again, the western shores of Britain uniformly experience higher tides than the eastern coasts, for their geographical position exposes them to the full force of the tidal wave, as it advances from the south-west. In the case of such estuaries as the Solway Frith, Morecambe Bay, and the mouth of the Severn, the shape of the land—narrowing upwards in the

direction in which the tidal wave advances—accounts for the great height of tide which is experienced. The advancing wave becomes, under such conditions, a *bore*, or head-wave, which rolls up with extraordinary velocity and force.

In the open ocean, where there is no resisting power to impede the steady onward flow of water, the height of the tides is inconsiderable. Upon the coasts of such islets as St Helena, Tahiti, or the numberless groups of the Pacific, the difference of level between high and low water rarely exceeds five or six feet. It is when the tidal wave meets, in its advancing course, with the resistance presented by lines of coast, that its flow is retarded, and its height becomes increased or diminished, in accordance with the particular geographical conditions of any given locality.

Inland seas seldom experience any considerable tides, and, in many cases, have no perceptible tide. Owing to the limited extent of such seas as compared with the great oceans, the lunar influence extends over too large a portion of their surface at the same instant of time to allow of the generation of any considerable tidal wave; for the tidal wave is only called into existence by drawing away the waters from one part to another part of the ocean. The Mediterranean is, for the most part, a tideless sea, though at the head of the Adriatic there is a rise and fall of a foot or two. The Red Sea, on the contrary, has considerable tides. The opposite sides of the isthmus of Suez hence experience widely different conditions in this regard. A like contrast is presented by the opposite shores of the isthmus of Panama. Upon the Atlantic coasts of that isthmus the tides are scarcely perceptible, while on the Pacific shores the difference of level between high and low water is upwards of 27 feet.

At the times of either new or full moon, the Sun, Moon, and Earth, occupy relatively to one another the same places in the heavens; hence high water at new and full moon, in any given locality, recurs at precisely the same hour. A line drawn on the map to connect places which are subject to like conditions in this regard—that is, a line connecting places which experience high water at new and full moon at the same hour—is called a *co-tidal line*. A series of co-tidal lines, drawn upon a map, with an indication of the hour proper to each, shows the advance of the tidal wave, and its rate of progress from one part of the coast to another part. Thus, it takes thirteen hours for the tidal wave to travel from the

coast of Tasmania to the Cape of Good Hope: in the succeeding eleven hours it reaches the Canary Islands, and in four hours more the western shores of Britain.

WAVES.—The most frequent and universal cause of disturbance in the surface of the ocean is found in the winds. These at one time raise a mere ripple upon the waters, and under other conditions lash them into fury, generating the great waves which accompany the storm. The height of waves generated in the open ocean has been, however, greatly exaggerated, as is shown by careful observations made within recent years. Dr Scoresby measured the height of the Atlantic waves, after a long-continued gale of the severest kind, by mounting to successive heights above the deck of the ship, until he could *look over* the crest of the approaching wave. He found that the mean highest waves reached a height of 43 feet above the level of the hollow occupied by the ship—the height above the mean level of the sea being, of course, only half that amount. The average height of the Atlantic waves does not exceed 24 feet from trough to crest, or half that number of feet above the mean level of the waters. The interval between the successive waves was estimated, on the same occasion, to be about 600 feet, and their rate of advance equal to 32 miles per hour. The remarks of other observers confirm these conclusions. But where the onward progress of the mass of water is resisted by any obstacle, as in a sea which dashes up against an iron-bound coast, the waves roll up to much greater height; as, under like conditions, they overtop piers or light-houses, while the almost resistless force of the watery mass frequently removes huge masses of rock. The construction of our piers and lighthouses has furnished instances of masses of rock weighing forty tons having been moved by the waves. It is thus that nature sports with the works of man.

IX.

THE ATMOSPHERE.

THE air, or atmosphere, is an invisible fluid which surrounds the globe, covering land and sea alike, and reaching from the surface of the earth upwards to a supposed height of about fifty miles. This fluid medium, or aërial ocean, is necessary to the existence of both vegetable and animal life, and forms the indispensable condition to the existence of man, as of every other animal. Atmospheric air is inhaled by us in every breath that we draw, and, after fulfilling its proper functions in the vital organisation of our bodies, is again exhaled in an altered form, for the purpose of playing a further part in the great economy of the natural world. It is thus that everything in nature is continually taking part in the admirable series of transformations of which the world of nature is composed. "The carbonic acid with which to-day our breathing fills the air, to-morrow seeks its way round the world. The date-trees that grow round the falls of the Nile will drink it in by their leaves; the cedars of Lebanon will take of it to add to their statures; the cocoa-nuts of Tahiti will grow rapidly upon it, and the palms and bananas of Japan will change it into flowers. The oxygen we are breathing was distilled for us some short time ago by the magnolias of the Susquehanna, and the great trees that skirt the Orinoco and the Amazon, the giant rhododendrons of the Himalaya, contributed to it, and the roses and myrtles of Cashmere, the cinnamon-tree of Ceylon, and the forests, older than the flood, buried deep in the heart of Africa, far behind the mountains of the moon. The rain we see descending, was thawed for us out of the icebergs which have watched the polar star for ages, and the lotus-lilies have soaked up from the Nile, and exhaled as vapour, snows that rested upon the summits of the Alps." *

* *North British Review*, quoted in Maury's "Physical Geography of the Sea."

Among other properties of the air is that of density, or weight. It presses upon everything on the earth's surface, with a force equal to nearly fifteen pounds to the square inch. This pressure undergoes progressive diminution with every stage of ascent above the ordinary level of the earth, and, with the diminished pressure exerted by its own weight, the air becomes, in its higher strata, more and more tenuous, or rare. This increased rarity of the air becomes painfully noticeable in the ascent of high mountains, and is often accompanied by difficulty of breathing, with other symptoms that have been frequently described by travellers.

It is the movements of the atmosphere that make its presence sensible to man, as to others of the earth's inhabitants, and these movements are a consequence of the readiness with which air yields to every pressure, and expands or contracts its volume with every variation of temperature. Wind is simply a portion of air in motion—air, that is, which is passing from one region of the atmosphere to another region. Warm air is specifically lighter than cold air. Hence, if from any cause a given portion of air has its temperature raised above the average temperature of the air with which it is in contact, it has at once a tendency to rise above the lower strata of the whole body of adjacent atmosphere, while its place is taken by the cooler portions of surrounding air. Two currents of air, or winds, are thus generated—an ascending current of warm air, and a horizontal current of cool air; and the movements thus called into being will continue in force until the general equilibrium of the whole is restored. The ascending current of warm air gradually parts with its heat as it reaches the upper strata of the atmosphere. Again, a sudden rise of temperature, that is, an accession of heat, causes air to expand in volume, while, on the other hand, a diminution of temperature occasions it to contract. Any such alteration in the volume of air necessarily affects the condition of adjacent portions of the entire body of the atmosphere, and currents of air, or winds, are set in motion thereby. The relative dryness, or moisture of the air, is another condition which affects its density, and tends, in consequence, to set its different portions in motion. Any accession of moisture adds to the weight of the air, as any abstraction of its contained moisture diminishes its density. Warm air is capable of holding in suspension a greater quantity of moisture than cold air, and this capability for

holding moist vapour increases up to the point of saturation; at this point, any diminution of temperature involves condensation of the vapour held in suspension, and produces rain.

The prevailing currents of the atmosphere, or winds, constitute an important feature in the climate of any country, and it belongs to Physical Geography to explain—in so far as they are capable of explanation—the prevalent winds which distinguish great regions of the globe. Such explanation is more easily made in regard to the warmer latitudes of the earth, where alone the direction of the winds is constant, than might be at first supposed by those whose personal experience is limited to such countries as Britain, and other temperate lands, where the variable condition of the atmosphere is the well-known subject of common observation and remark. But within those parts of the globe which experience a vertical sun, and for a few degrees beyond the exact line which marks the limit of the sun's vertical influence on either side of the equator, the conditions either of perennial calm, or of currents of air that constantly blow in one given direction, are the uniform characteristics of climate.

That such atmospheric conditions should be limited to the lower latitudes of the globe is readily accounted for, when we consider the vastly greater power of the sun in those regions, due to the vertical (or nearly vertical) rays which the great luminary there throws upon the earth. It is from the sun that all the heat of our globe's surface is derived, and we accordingly regard the sun as the great cause of all variations in temperature which different regions of the earth experience. The various distribution of land and sea, and the varying angle at which the sun's rays meet the surface of either, account for difference of heat and other conditions of climate. These conditions are naturally marked out with most distinctness in regions where the agency of heat is experienced with most intensity—that is, within the limits of a vertical (or nearly vertical) sun. The line of the tropic marks the precise limit of the sun's vertical rays; but the actual amount of heat experienced upon one side of that line differs in scarcely perceptible measure from that felt immediately on its opposite side, for the gradations between heat and cold—like those between light and darkness, or between spring and summer—are incapable of being marked by the precise lines

which the mathematician draws upon his diagram, or marks out upon the artificial globe. The heat of intra-tropical regions passes, by successive gradations, into the cool temperature of the middle latitudes, as the last does into the cold of the regions that lie around the poles; but the stages of this passage are gradual. Hence the influences of a vertical sun prevail for a few degrees beyond the line which mathematically marks the limit of our great luminary's strictly vertical rays. In other words, the sub-tropical regions, for a few degrees on either side of the torrid zone, share the characteristics of that zone, not merely as concerns temperature, but as respects all the phenomena of meteorology, and their external limit varies with the alternate presence of the sun to the northward or the southward of the equator.

Let us see how the above considerations apply to the great conditions of climate which distinguish—1st, The regions of almost perennial calm; 2d, Of constant winds, blowing uniformly in one direction; and, 3d, Of periodical winds, the precise and well-known direction of which recurs with each returning season:—

1. The Calm Latitudes.—Throughout a zone of a few degrees in breadth, which extends round the globe in the neighbourhood of the equator, and the limits of which undergo a certain amount of variation, dependent on the sun's passage of the equinox, the variation of temperature throughout the year is confined within very narrow limits, and the result is a general prevalence of calms—that is, of undisturbed atmosphere. Wind is air set in motion, mainly by the existence of different conditions of temperature between adjacent bodies of air—of colder and denser air pressing against warmer and lighter air, and taking the place which is left vacant by the latter, as it rises into the higher regions of the entire aërial sea. Between the heated air of the tropics in general, and the comparatively cooler air of the regions lying some distance north and south of the tropics, for example, there is a very manifest difference as to temperature, as well as in regard to other conditions; but for a few degrees in the immediate neighbourhood of the equator there is no such obvious difference, and, consequently, nothing to occasion disturbance (temperature alone being considered) in the general equilibrium of the atmosphere. Hence the prevalence

of calms in that region. Within the parallels of 8° or 10° on either side of the line, the angle at which the solar rays reach the earth is at no time more than a few degrees from the perpendicular, for the equator divides the total amount of angular difference which is involved in the entire yearly path of the sun.

The average breadth of the calm latitudes—or the Zone of Calms, as it is the custom, in books and maps, to term it—may be stated at about six or seven degrees. The mid-line of this zone does not coincide with the equator, for the reason that the equator does not represent the line of the earth's highest temperature, owing to the preponderance of land in the northern hemisphere. Hence the Zone of Calms is, for the most part, to the northward of the equator—extending, with varying seasonal limits, from about the first to the seventh or eighth parallel of north latitude. But its limits oscillate, with the sun's passage of the equinox and consequent place in the heavens vertically over either side of the equator. "In July and August," (says Maury,) "the Zone of equatorial Calms is found between 7° north and 12° north—sometimes higher; in March and April, between latitudes 5° south and 2° north. . . . . This belt of calms travels during the year, back and forth, over about 17° of latitude, coming further north in the summer, where it tarries for several months, and then returning so as to reach its extreme southern latitude some time in March or April." It thus moves over more than double its average breadth, and forms, in fact, an oscillating belt of the globe, within which belt the predominating condition of the air is that of intense and nearly unvarying heat, accompanied by a stillness that is only broken at rare intervals.

The calm latitudes are the dread of the mariner, whose ship is often delayed for weeks together within their limits. The wearisome and tantalising nature of this delay can, perhaps, only be adequately appreciated by those who have experienced the monotony attendant on a calm in mid-ocean, when, with a still and glassy sea around, a glittering atmosphere, and a burning sun overhead, the sails hang idly by the yards, and the vessel makes no appreciable progress. The often-quoted words of "The Ancient Mariner" possess literal truth :—

"The sun came up upon the left,
  Out of the sea came he;
And he shone bright, and on the right
  Went down into the sea.

* * * * *

"Down dropp'd the breeze, the sails dropp'd down;
'Twas sad as sad could be:
And we did speak, only to break
The silence of the sea.

"Day after day, day after day,
We stuck, nor breath nor motion,
As idle as a painted ship
Upon a painted ocean."

But the prevailing calm of these latitudes is disturbed, at uncertain intervals, by the sudden gale which springs up—probably under electrical influences, for, as we have already intimated, temperature is not the sole agent of disturbance in the atmospheric equilibrium—and under the influence of which the dreaded region is passed. The mariner rejoices at his escape from its limits, and enters a region within which steady and uniform currents of air are experienced, and in which, accordingly, his vessel can make the surest advance on her voyage.

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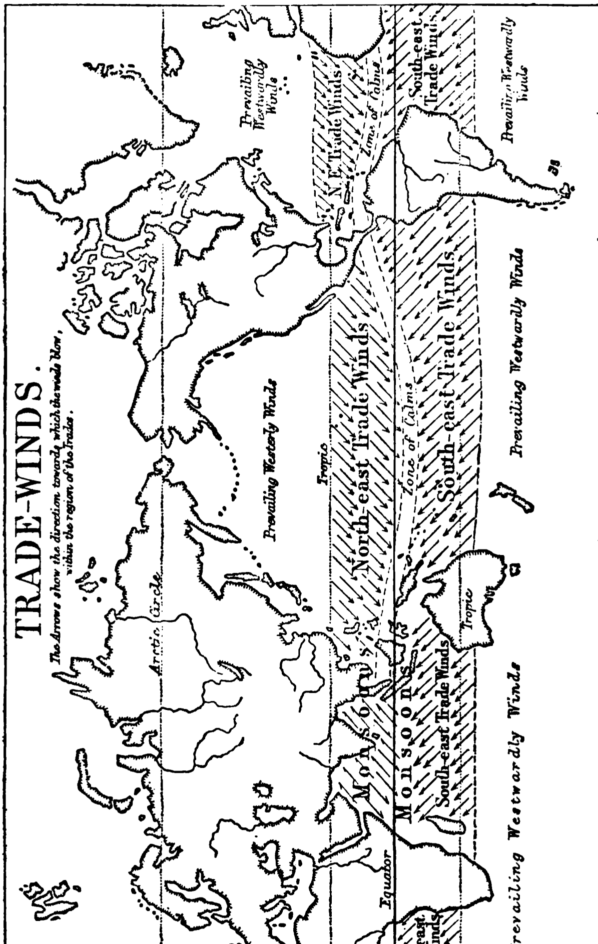
2. THE TRADE-WINDS. Between the oscillating limit of the zone of calms and the parallel of 28° in the northern hemisphere, on one side of the globe, and between the correspondent limit and the parallel of 25° south latitude, on the opposite hemisphere, there prevail, through above two-thirds of the earth's circumference, steady winds, blowing with almost undeviating uniformity from the eastward. These are the trade-winds. More precisely, *the trade-wind of the northern hemisphere is a wind blowing from the north-eastward*—that is, *a north-east wind. The trade-wind of the southern hemisphere blows from the south-eastward*, and is *a south-east wind.*

The extreme north and south limits of the trade-winds, like their limits towards the equator, are not fixed. They fluctuate with the presence of the sun over the northern or the southern half of the torrid zone. The trade-wind of the northern hemisphere is perceptible a few degrees further north, during the summer of that half of the globe, than is the case at the opposite season of the year; and the like wind of the southern hemisphere is experienced further to the south, during the time that the sun's course is between the equator and the southern tropic, than during the half of the year when that luminary is north of the equator. The trade-winds thus form oscillating belts of the atmosphere, divided by a zone of


TRADE-WINDS.
The Arrows show the direction towards which the winds blow, within the region of the Trades.
Arctic Circle
Tropic
Equator
Prevailing Westerly Winds
Prevailing Westwardly Winds
North-east Trade Winds
N. E. Trade Winds
Zone of Calms
South-east Trade Winds
Monsoons
Prevailing Westwardly Winds

calms, itself also oscillating. But although the external limits of these wind are subject to variation, there is comprehended within them a broad belt—embracing from twelve to fifteen degrees of either hemisphere—within which the winds blow constantly, in the one hemisphere from the north-east, and in the other hemisphere from the south-east.

The trade-wind belts stretch round more than two-thirds of the earth's surface. They comprehend (within the latitudinal limits already defined) the Atlantic and Pacific Oceans, with the countries that lie adjacent to those vast areas of water. In the Pacific, however, their limits are less distinctly marked, and their influence less powerful, to the southward of the equator than to the north of that line. Over the Indian Ocean and its shores, the atmospheric currents follow, during portions of the year, an opposite course, as will be afterwards explained.

The trade-winds of the Atlantic and Pacific—blowing constantly, and with almost undeviating steadiness, from the eastward—regulate the course of the mariner across those oceans. They of course facilitate the passage of either ocean in a westerly direction—that is, from the shores of the Old World to the eastern sea-board of America, or from the western coasts of the New World to the eastern shores of the Asiatic and Australian continents. It was the trade-wind of the Northern Atlantic that carried Columbus to the westward, on the adventurous voyage which resulted in the discovery of the New World, inspiring terror in the breasts of his companions, while in the mind of the great navigator himself it strengthened the assurance of reaching land by pursuing the direction in which his vessels' prows were turned. On a like great occasion, the trade-winds of the Pacific carried Magellan's ship steadily forward through the ocean which he was the first to cross, and facilitated the earliest circumnavigation of the globe. On the other hand, the same winds compel the return voyage across either ocean to be made in higher latitudes, where westerly winds prevail.

The explanation of the trade-winds is found in the different measure in which the sun's heat is experienced by regions within or nearly adjacent to the tropics, and by those of higher latitudes. They are currents of air set in motion by the differences of density consequent upon such various conditions of temperature—conditions which are of uniform prevalence, and the result of which is hence also constant.

The portions of atmosphere which, in either hemisphere, are heated by the rays of a vertical (or nearly vertical) sun, become, from this higher temperature, specifically lighter than the adjacent columns of air within higher latitudes. They have hence a tendency to rise into the upper strata of the entire body of atmosphere, while the cooler and denser air of higher latitudes is set in motion towards the place left vacant by the ascending currents, and tends to spread over the lower strata of the whole. In other words, the trade-winds are the cooler air of temperate and higher latitudes, in either hemisphere, moving towards the warmer zone of the earth, to replace the rarefied atmosphere of these regions. These currents of cool air become noticeable, as winds moving over the earth's surface, within a few degrees of either tropic, because, as the neighbourhood of the tropics (and consequently of vertical heat) is approached, the conditions of difference between the atmospheric temperature of different regions of the globe become more strongly marked. Thence through a belt of varying limits on the side of the equator, but averaging about fifteen degrees of either hemisphere, the north-east currents of air which form the trade-wind of the northern half of the globe, and the south-east currents which are the trade-wind of the southern half of the globe, are constant—in so far as the Atlantic and Pacific Oceans, with their shores, are concerned. But as the region of equatorial heat is approached, (and through several degrees before the equator is actually reached,) the conditions of atmospheric temperature become, with each degree of latitude, more and more uniform. The steady current of the trade-wind begins to fail, and at length altogether ceases. The belt of the calms is entered, when, through a space comprehending several degrees upon either side of the equator of temperature, the condition of the atmosphere is one of uniform heat and consequent equilibrium of density, subject only to such disturbances as are connected with electric agency.

An explanation of the westerly course of the trade-winds is found in the fact of the earth's diurnal rotation. In this respect, what has been said under the head of oceanic currents * is equally applicable to the question of atmospheric currents, or winds. If, instead of rotating on its axis, the earth were at rest, we may assume that the currents of air which advance from polar and temperate latitudes towards the equator would follow the direction of the meridian—that

* Page 96.

is, the wind of the northern hemisphere would be a north wind, and the like wind of the southern hemisphere would be a south wind. But the atmospheric currents of high latitudes possess a lower rate of axial motion than belongs to the regions towards which they are advancing, and hence—left in some degree behind the eastwardly motion proper to those parts—they acquire a westwardly direction: that is, the wind of the northern hemisphere, instead of a north, becomes a *north-east* wind, and the wind of the southern hemisphere, instead of being a south, becomes a *south-east*, wind.*

To sum up, we may say that the trade-winds, like the currents of the ocean, are due, first, to the Sun, that is, to the different measure in which the solar heat is distributed on the globe's surface; and, second, to the Earth's axial rotation, which affects the direction of currents in the aerial ocean in manner precisely analogous to that in which it affects the like currents in the aqueous ocean. In truth, the ocean of water, and the ocean of air—in contact with one another, and possessing many properties in common—act and re-act upon one another, mutually imparting their respective temperatures, movements, and other conditions. This is only one among the instances of mutual harmony—one of the many mute sympathies—which abound in the natural world. †

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3. THE MONSOONS are winds which blow over the Indian Ocean and the countries adjacent to its waters. In general terms, it may be said that they prevail within the same latitudes as those over which the trade-winds of the Atlantic and Pacific blow. But the monsoons differ from the trade-

* A north-east wind, it will be remembered, has a *direction towards the south-west*, and, similarly, a south-east wind blows *towards the north-west*. A wind is spoken of by reference to the quarter whence it blows: thus, by a north wind is meant a wind blowing from the north. The reverse is the case with the currents of the ocean, which are always referred to the direction *towards which they flow*. A northerly current is a current setting *towards* the north. The equatorial currents of the Atlantic and Pacific are westerly currents—that is, they set to the westward. The trade-winds of the same oceans have the same general direction, but their distinctive names, as winds, are derived from the opposite quarter of the heavens.

† The explanation of the trade-winds above given is essentially the same as that offered, upwards of a century and a half since, by the astronomer Halley, and afterwards added to by Hadley (*Philos. Transac.* 1735). This explanation has been adopted, with trifling modification, by nearly all subsequent writers on the subject. But the existence of the Belt of Calms appears unaccountably to have been a source of difficulty, whereas it surely follows, from the very assumption of difference of temperature and consequent density in ad-

winds of the two greater oceans in the fact that they are *periodical winds*—not perennial. The monsoon blows for half the year from one quarter of the heavens, and for the other half from an opposite quarter.

Over the northerly portion of the Indian Ocean—from the neighbourhood of the equator to the shores of the Asiatic continent, including the East Indian archipelago and the adjacent China Sea—a north-east monsoon blows during the winter months of the northern hemisphere, that is, from

joining atmospheric columns as the cause of winds setting from colder to warmer latitudes, that within latitudes of uniform (or nearly uniform) heat and consequent uniform density there will be no appreciable motion. Writers on this subject appear to have forgotten that it is not the absolutely high temperature, *per se*, of the torrid zone which occasions winds, for if the same condition of atmospheric temperature prevailed over the entire globe, there would be uniformity of density, and consequently no impelling cause of wind. It is the *difference of comparative temperature and consequent density* between adjacent regions of the whole aerial ocean that sets currents of air in motion. This difference is most marked, upon the earth's surface, about those parallels where the contrast between conditions of heat consequent on a nearly vertical sun and those proper to temperate latitudes is first distinctly noticeable—that is, within a few degrees of either tropic. It becomes less and less noticeable as the region of greatest and *most equable* heat is approached. The atmospheric currents consequently fail as the equator of temperature is neared. The trade-wind, long a steady breeze, becomes gradually uncertain: light and fluctuating winds take its place, as either pole-star sinks nearer and nearer to the horizon: at length the wind fails altogether, and uniform calm succeeds.

It has often been said, in the vain attempt to furnish any other than the above simple explanation of the calm belt, that the north-east and south-east trade-winds of the opposite hemispheres meet one another, and so neutralise one another's action. But there is, in truth, no such meeting. The trades begin to fail, as has been just observed, long before the calm latitudes are actually reached; and the calm belt, like the inner limits of the trades themselves, continually moves up and down with the transit of the sun from one side of the equinox to the other.

It will be seen that I do not adopt the explanation given by the author of "The Physical Geography of the Sea" of the movement of the atmospheric currents. I dissent altogether from the theory which that explanation involves—viz., the passage of the trade-winds of one hemisphere to the opposite side of the earth, so that the regions of evaporation to the south of the equator become the source of the rain-fall belonging to the northern hemisphere, and the reverse. This attempted explanation seems to me altogether wanting in simplicity, and appears only calculated to create difficulty and needless complication. Nor does the scanty array of facts adduced by its author appear at all sufficient to bear out his hypothesis: certainly none of these facts are in any way incompatible with the simpler explanation adopted in the text. Physical geography owes so much to Lieutenant Maury, as a diligent collector of facts, of which his own arrangement (on the invaluable "Wind and Current Charts") first demonstrated the full importance, that I should express this dissent from the theory propounded in his chapter on the Atmosphere with the more hesitation, were it not that I am able to fortify myself on this head by the opinion of the able writer of the article on Physical Geography in the eighth edition of the "Encyclopædia ·itannica."

October to March, inclusive. During the summer months—April to September—and within the same limits, the south-west monsoon blows.

Southward from the equator to the neighbourhood of the tropic of Capricorn, the south-east monsoon blows during the winter of those latitudes (April to September): this is exchanged, during the other half of the year, for a north-west monsoon in the neighbourhood of the Australian coasts, and for a north-east monsoon along the line of the African shores. The term *monsoon*—derived from a Malay word which signifies "season"—expresses the periodical nature of these winds, and indicates to how large an extent the climate of Indian seas and lands is dependent upon their periodical recurrence.

It hence appears that, during half the year, the monsoon of the Indian Ocean coincides in direction with the trade-wind of the Atlantic and Pacific—that is, it is on one side of the equator a wind from the north-east, and on the other side a wind from the south-east. During half of the year only does the monsoon exhibit a deviation from the normal course of the atmospheric currents proper to such latitudes, and the general explanation of which has already been given. The smaller limits of the Indian Ocean, and the striking points of geographical distinction between its basin and those of the two other great oceans, readily serve to explain this partial reversal of the atmospheric currents which characterise correspondent latitudes elsewhere.

In the case of the Atlantic and Pacific Oceans, we have not only a vastly greater expanse of water, but we have unbroken continuity of water, stretching north and south, in the direction of the poles. There is, throughout vast spaces, nothing to impede the operation of those natural laws by which the circulation of the atmospheric currents is regulated, and the agency in which is almost uniform over great expanses of water. The Indian Ocean, on the contrary, besides being of greatly inferior dimensions, is closed to the northward by land. The high-lands, mountain-ranges, and extensive coast-plains, which shut in the Indian Ocean upon three sides, undergo great variations of temperature with the passage of the sun from north to south declination, (or the reverse,) and the heated currents of air which rest upon those lands occasion a reversal, during the period of intensest heat, of the winds which are proper to such parallels.

It is during the summer months of either hemisphere, that

the reversal of the ordinary trade-wind of the tropics occurs. During the half-year from April to September, the sun is vertically over the lands of southern Asia. The intense heat then experienced by these lands occasions the warm and rarefied air to rise, and currents of cooler air from the adjacent sea set in to take its place. It is thus that a south-west monsoon is generated on the Indian shores, and prevails, with more or less intensity, over large portions of the adjacent ocean, including the islands of the Eastern Indies. With the return of the sun to the south of the equator, the ordinary trade-wind, (that is, the north-east monsoon,) resumes its place, for the cause of excessive heat and consequent atmospheric disturbance is then withdrawn.

Again, during the months between October and March, the summer of the southern hemisphere, the glowing rays of a vertical sun, shining upon the arid plains of North-Western Australia, occasion excessive heat and consequent rarefaction. The warm air of those regions ascends, and the currents of cooler air which set inland from the adjacent sea constitute a north-west monsoon. The like cause produces, in the vicinity of the East African shores, a north-east monsoon. But when, with the returning winter of the southern hemisphere, the sun has again passed to the northward of the equator, the south-east monsoon, the ordinary trade-wind of southern latitudes, resumes its place.

The sun is thus the cause of the monsoons, as of the trade-winds of the Atlantic and Pacific Oceans. The monsoons, in reality, are nothing more than those winds, reversed during half the year, by a cause of which ready explanation is found in the geographical conformation of the lands and seas within which they prevail.

The change from the one monsoon to that from an opposite quarter is not accomplished at once. The breaking-up of the monsoon, as it is termed, is attended by thunder-storms and other meteorological phenomena, which prevail during some weeks, until the setting-in of the coming monsoon is fairly accomplished. The nature of these changes, and the general characteristics of the monsoon itself, are admirably depicted in the following passage, by a master-hand.

"Meanwhile the air becomes loaded to saturation with aqueous vapour drawn up by the augmented force of evaporation acting vigorously over land and sea: the sky, instead of its brilliant blue, assumes the sullen tint of lead, and not a

breath disturbs the motionless rest of the clouds that hang on the lower range of hills. At length, generally about the middle of the month, but frequently earlier, the sultry suspense is broken by the arrival of the wished-for change. The sun has by this time nearly attained his greatest northern declination, and created a torrid heat throughout the lands of southern Asia and the peninsula of India. The air, lightened by its high temperature and such watery vapour as it may contain, rises into loftier regions and is replaced by indraughts from the neighbouring sea, and thus a tendency is gradually given to the formation of a current bringing up from the south the warm humid air of the equator. The wind, therefore, which reaches Ceylon comes laden with moisture, taken up in its passage across the great Indian Ocean. As the monsoon draws near, the days become more overcast and hot, banks of clouds rise over the ocean to the west, and in the peculiar twilight the eye is attracted by the unusual whiteness of the sea-birds that sweep along the strand to seize the objects flung on shore by the rising surf.

"At last the sudden lightnings flash among the hills and sheet through the clouds that overhang the sea, and with a crash of thunder the monsoon bursts over the thirsty land, not in showers or partial torrents, but in a wide deluge, that in the course of a few hours overtops the river banks and spreads in inundations over every level plain.

"All the phenomena of this explosion are stupendous: thunder, as we are accustomed to be awed by it in Europe, affords but the faintest idea of its overpowering grandeur in Ceylon, and its sublimity is infinitely increased as it is faintly heard from the shore, resounding through night and darkness over the gloomy sea. The lightning, when it touches the earth where it is covered with the descending torrent, flashes into it and disappears instantaneously; but when it strikes a drier surface, in seeking better conductors, it often opens a hollow like that formed by the explosion of a shell, and frequently leaves behind it traces of vitrification. In Ceylon, however, occurrences of this kind are rare, and accidents are seldom recorded from lightning, probably owing to the profusion of trees, and especially of cocoa-nut palms, which, when drenched with rain, intercept the discharge, and conduct the electric matter to the earth. The rain at these periods excites the astonishment of a European; it descends in almost continuous streams, so close and so dense that the level ground,

unable to absorb it sufficiently fast, is covered with one uniform sheet of water, and down the sides of acclivities it rushes in a volume that wears channels in the surface. For hours together the noise of the torrent, as it beats upon the trees and bursts upon the roofs, flowing thence in rivulets along the ground, occasions an uproar that drowns the ordinary voice and renders sleep impossible." *

The monsoons of the Indian Ocean are not divided by any such distinctly-defined belt of calms as separates the opposite trade-winds of the northern and southern Pacific and Atlantic.† The south-east monsoon of the southern Indian Ocean passes gradually into the south-west monsoon, which prevails at the same time in the northern half of that ocean. Nor is the season of change from the one monsoon to the other precisely the same over all parts of that ocean. Indeed, the Indian Ocean, from the geographical conditions already adverted to, is exposed in much higher measure than either of the other oceans to the disturbing influences consequent upon proximity to land, and its winds are hence affected in a vastly greater degree by local conditions. Thus the Indian monsoon, the Arabian and East African monsoon, and the monsoon of north-western Australia, assume in each case a direction which is dependent upon the geographical position and contour of the lands whence they derive their distinguishing names. In the Red Sea, the monsoons follow the direction of its shores, and blow, for six months of the year alternately, up and down its long and trough-like valley, confined and guided in their passage by the mountain-chains which bound it upon either side.

We have hitherto spoken of the monsoons only in connexion with the Indian Ocean. But, in truth, a monsoon, or season-wind—which is what the word monsoon means—is experienced upon a large portion of the west African coasts, and thence far out into the mid-Atlantic, within the proper region of the Atlantic trades. The evidence of this is one among the many valuable results due to the Wind and Current Charts of Lieutenant Maury, and the cause of it is precisely the same as that which occasions the monsoon of the Indian coasts.

* Ceylon. By Sir E. Tennant: London, 1859.
† Maury: Physical Geography of the Sea.

Between the equator and the parallel of 13° north, the intense heat of a vertical sun, acting upon the western coasts and adjacent interior of the African continent, occasion a reversal of the ordinary wind of that region. The intensely-heated atmosphere of the land, owing to superior rarity, ascends, and the cooler air of the neighbouring sea sets in to fill its place. The monsoon thus generated lasts as long as the sun remains to the northward of the equator. Further to the south, a like phenomenon accompanies, in those localities, the passage of the sun into south declination. The influence of these monsoons extends to a distance of a thousand miles or more from land, the entire space within which they prevail forming a cuneiform (or wedge-shaped) region in the midst of the Atlantic, the base of which rests upon the African continent, while its apex is within ten or fifteen degrees of the mouth of the Amazon.*

A similar reversal of the trade-winds of the North Pacific occurs off the western shores of Central America, capable of explanation in precisely like manner—due, that is, to the excess of heat which the summer sun brings to the adjacent lands, and the consequent rarefaction and rising of the currents of air over those lands. This, and the like instance of the west African monsoons, show in the most striking manner how powerfully the land is affected by the sun's heat, and to how wide a distance the atmospheric movements which are generated by such influences extend over the adjacent seas. Even such limited tracts of land as the Society and Sandwich Islands have a marked influence upon the winds experienced over the surrounding waters. They interfere, says Maury, with the trade-winds of the Pacific very often, and even turn them back, for westerly and equatorial winds are common at both groups, in their winter time.

LAND AND SEA-BREEZES.—Upon the coasts of most countries that are within the warmer latitudes of the globe, there occur daily, at or shortly before the hour of early dawn in the one case, and towards the approach of sunset in the other, breezes that blow respectively *off the shore* or from *off the adjacent waters*. The former is known as the land-breeze; the latter as the sea-breeze. These refreshing movements of the air are

* Maury.

not confined to countries within, or even very near to, the tropics, though they are more powerful in the case of countries that are within the torrid zone than in the case of other lands. But they are felt upon the coasts of the Mediterranean, and in even much higher latitudes than those of the Mediterranean, during the warmer portions of the year. The hour at which they begin to be perceptible is not the same in all localities; but, speaking generally, the land-breeze begins to be felt about an hour before sunrise, and the sea-breeze towards the early evening, as the time of sunset approaches. During the mid-day hours, the intense heat of the atmosphere, accompanied by general calm and almost perfect repose of the animal world, is painfully felt by all residents in warm countries, and the cooling sea-breeze which sets in as the sun approaches the horizon is welcomed with intense delight. To the sojourner in Indian lands, it is the signal for out-door exercise, and is accompanied by a general re-awakening of the outer world of nature. The dweller on the African or Australian coasts equally rejoices in its refreshing power. The mariner within Indian seas, frequently becalmed during the stillness of the night-watch, finds like relief in the breeze which blows off the land with the approach of early morning.

The land and sea-breeze are due to a cause strictly analogous to that which produces the monsoon of eastern seas—that is, the influence of the sun, heating in various measure the lands and seas, and with them the superincumbent air. Successive movements are generated in the atmosphere according as different portions of the whole acquire, with difference of temperature, various degrees of density. During the hours of mid-day heat, the air over the land becomes relatively hotter, by many degrees, than the air which is above the adjacent water, for it is the well-known attribute of land to experience much greater extremes of temperature than water does. As afternoon, with its sultry temperature, advances, this continued heat occasions the land-air to form an ascending current, while the cooler (and relatively denser) air from the neighbouring waters flows in to take its place. This cooling breeze is an effort of nature to restore equilibrium in the atmosphere, the heavier portions of the whole body of air assuming the place of lower strata, and the lighter portions spreading over the superior regions. This effort continues until the desired balance is attained, and, with the approach of midnight, the air is again calm and settled. But during

the night, while the water retains a nearly uniform temperature, the land rapidly parts with its heat, so that the air over the land becomes at length colder than that over the water. This latter, therefore, relatively the warmer of the two, tends to rise, while the cooler air of the land fills its place. A wind blowing from off the land is thus generated. In some localities, this blows during great part of the night. But the period of its commencement varies in different places, and the intervals of calm between both land and sea-breezes are often of uncertain duration.

"These sea-breezes"—we transcribe the quaint but expressive language of Dampier—"do commonly rise in the morning about nine o'clock, sometimes sooner, sometimes later. They first approach the shore so gently, as if they were afraid to come near it; and ofttimes they make some faint breathings, and, as if not willing to offend, they make a halt, and seem ready to retire. I have waited many times, both ashore, to receive the pleasure, and at sea, to take the benefit of it. It comes in a fine, small, black curl upon the water, when as all the sea between it and the shore not yet reached by it is as smooth and even as glass in comparison. In half an hour's time after it has reached the shore, it fans pretty briskly, and so increaseth gradually till twelve o'clock—then it is commonly strongest, and lasts so till two or three a very brisk gale. . . . These winds are as constantly expected as the day in their proper latitudes, and seldom fail but in the wet season. On all coasts of the main, whether in the East or West Indies, or Guinea, they rise in the morning, and withdraw towards the evening: yet capes and headlands have the greatest benefit of them, where they are highest, rise earlier, and blow later. Land-breezes are as remarkable as any winds that I have yet treated of: they are quite contrary to the sea-breezes; for those blow right from the shore, but the sea-breeze right in upon the shore; and as the sea-breezes do blow in the day and rest in the night, so, on the contrary, these do blow in the night and rest in the day, and so they do alternately succeed each other. For when the sea-breezes have performed their offices of the day, by breathing on their respective coasts, they, in the evening, do either withdraw from the coast, or lie down to rest. Then the land-winds, whose office is to breathe in the night, moved by the same order of Divine impulse, do rouse out of their private recesses, and gently fan the air until the next morning; and then their task ends, and they leave

the stage. There can be no proper time set when they do begin in the evening, or when they retire in the morning, for they do not keep to an hour. . . . . They both come and go away again earlier or later, according to the weather, the season of the year, or some accidental cause, from the land ; for on some coasts they do rise earlier, blow fresher, and remain later, than on other coasts. . . . . These winds blow off to sea, a greater or less distance, according as the coast lies more or less exposed to the sea-winds ; for in some places we find them brisk three or four leagues off shore, in other places not so many miles, and in some cases they scarce peep without the rocks, or, if they do sometimes in very fair weather make a sally out a mile or two, they are not lasting, but suddenly vanish away, though yet there are every night as fresh land-winds ashore at those places as in any other part of the world. . . . . The sea-breezes, indeed, are very comfortable and refreshing ; for the hottest time in all the day is about nine, ten, or eleven o'clock in the morning, in the interval between both breezes ; for then it is commonly calm, and then people pant for breath, especially if it be late before the sea-breeze comes, but afterwards the breeze allays the heat. However, in the evening again, after the sea-breeze is spent, it is very hot till the land-wind springs up, which is sometimes not till twelve o'clock, or after."

The land and sea-breezes repeat, on a scale of diurnal variation, the phenomena shown by the monsoons on a scale of yearly change. They show how readily the atmosphere yields to the slightest pressure, and how powerful an influence on the laws of climate, and, with them, on the condition of mankind, is exercised by every change, of temperature or otherwise, to which it is subject.

WINDS OF HIGH LATITUDES.—Within the middle and higher latitudes of the globe, from the outer limits of the trade-winds of either hemisphere towards the direction of the poles, no such uniformity is found in the direction of the atmospheric currents as belongs to the winds of tropical seas and lands. With every advance into higher latitudes, not only does the sun's heat become less considerable, and the cause of periodical or constant movement in the atmospheric

currents less intense in its action, but there is increasing variation in the respective length of day and night at opposite seasons. Moreover, it is in the north temperate zone of the earth that the land bears the largest proportion to the water,* and that—at least in so far as the lands and seas within the northern half of the globe are concerned—the elements of uncertainty in the movements of the air are found in largest measure. The entire problem of atmospheric change, so to speak, is more complex under such conditions than is the case within tropical latitudes and under conditions of tropical heat.

Within the temperate latitudes of the great oceans, however, from about the parallel of 30° on either side to the neighbourhood of the polar circles, the prevailing winds are *from the westward.* These westerly winds of middle latitudes are by no means correspondent in regularity to the steady easterly breezes of tropical seas. They are, on the contrary, of uncertain occurrence and duration, often separated by intervals of contrary movements in the air, and at all times liable to interruption by violent disturbance, or storm. Still, in the average of any given period of time, the westerly winds experienced within such localities exceed those that blow from other quarters of the heavens in a large numerical ratio. These westerly winds facilitate the return across the great ocean of ships which have made their outward voyage, in the opposite direction, under the influence of the trade-winds of the tropics. The homeward voyage from the North American sea-board to the shores of Western Europe; the route from China and Japan to the western coasts of the New World; or the like voyage, within southern parallels, from Australia towards the shores of Chili; and the outward voyage from Britain, past the Cape of Good Hope, through the southerly latitudes of the Indian Ocean, to the coasts of western Australia, are accomplished by aid of the winds of middle latitudes, blowing, for the most part, from the westward.

The limit between these prevailing westerly currents of air and the trade-winds is marked by an interval of uncertain breezes and frequent calms. These calms of temperate latitudes are generally experienced by the mariner about the 28th or 30th parallels of either hemisphere, (somewhat nearer to

* See page 13. It is only in the north temperate zone that the land and water cover nearly equal portions of space. Elsewhere, the water is everywhere greatly in excess of the land.

the equator in the southern than in the northern half of the globe,) as he approaches the region of the well-known trades, or easterly breezes, which belong to warmer skies.

The prevailing westerly winds of middle latitudes are to be regarded, in the great system of atmospheric movements, as compensating currents for the trade-winds, which, within lower parallels, blow from an eastwardly direction. They are, in fact, the returning currents of tropical latitudes, which, by their ascent into the higher regions of the air, have become cooled in temperature, and, from the density thus acquired, sink towards the surface of the earth, to replenish the source whence the constant indraught of the tropics is supplied. Their eastwardly direction is accounted for by the same consideration which explains the eastwardly movements of the ocean-currents within similar latitudes, and which explains the westwardly course of the intra-tropical currents of air and water alike—that is, the earth's rotation. Advancing, on their return course, from equatorial towards polar regions, their normal direction is along the meridian; but the superior rate of rotary movement, acquired in the regions whence they originally set out, gives them an advance to the eastward beyond that proper to the latitudes into which they are travelling. Hence the general *direction* of north-east (that possessed by a S.W. wind) within the middle latitudes of the northern hemisphere, and that of south-east (proper to a N.W. wind) within similar latitudes south of the equator. The conflict which, in their return to the earth's surface, from the prior condition of upper currents, they have to maintain with the surface currents of air advancing towards the equator—to feed the trade-winds regions—accounts, at least in some measure, at once for the irregularity of movement which generally marks the winds of middle latitudes, and for the frequent and violent gales to which such latitudes are liable.

The easterly winds of the tropics, and the prevailing westerly winds of middle latitudes, alike form parts of a great system of atmospheric movements, through the agency of which the whole body of air is maintained in circulation, and uses to man thereby developed in their fullest proportions. The general direction of these movements is the same in the aerial ocean as in the ocean of water, and may, for the sake of a broad generalisation, capable of being easily retained in the memory, be thus expressed—

1. Within the warmer latitudes of the globe, the winds, and also the oceanic currents, have a prevailing *direction* to the westward.
2. Within middle latitudes, the prevailing winds, and also the principal oceanic currents, have a *direction* to the eastward.
3. Within high latitudes, the prevailing *direction*, of winds and currents alike, is from the poles towards the equator—that is, from north to south in the northern hemisphere, and from south to north in the southern half of the globe.

Over the land, with its infinitely-varied surfaces, the winds exhibit, especially within temperate and higher latitudes, conditions of change which are much more irregular and complicated, and which form a highly important feature in the general subject of climate.

The rotary storms which occur, at uncertain intervals, in particular latitudes, are to be included amongst the exceptional phenomena of atmospheric change. They prevail, however, over larger areas than was formerly supposed, and perhaps belong to a general system of atmospheric movements in which electric and magnetic influences fill an important place. The hurricanes of the West Indies, the tornadoes and cyclones of the Indian Ocean, and the typhoons of the China Sea, are winds of this description. Within the southern hemisphere, the direction of the rotating circle is always found to correspond to the movement of the hands of a watch, (*i.e.*, from west to north, east, and south:) to the north of the equator, the circle of wind follows an opposite direction, (or west to south, east, and north.) By a knowledge of this law, combined with careful observation of the track usually taken by such storms, mariners are enabled to avoid some of the dangers incident to their occurrence.

Water-spouts are another form in which the rotary movements of the air are manifested. In the case of these phenomena, a taper column of cloud, descending from above, is joined by a spiral column of water which winds upward from the agitated surface of the sea, the two together forming by their union a continuous column which moves over the sea. Water-spouts seldom last longer than half-an-hour. They are more frequent near the coast than on the high seas; and are more commonly seen in warm climates.

I.

CLIMATE.

All the conditions of Physical Geography which have been described in the foregoing chapters enter into the constitution of Climate, and combine to produce it as their joint result. The arrangement of land and water, the areas of drainage possessed by different countries, the geological formation of the soil, the position and movements of the ocean, the phenomena of the atmosphere, and, above all, the various measures in which the direct solar heat is communicated, constitute conditions of physical climate. And according to the various degrees in which such conditions are combined in the case of any particular region, is it suitable for the abode of man.

Among the conditions above glanced at, those which are most important, and which determine, for the most part, the general characteristics of the climate of a country, are the three following—

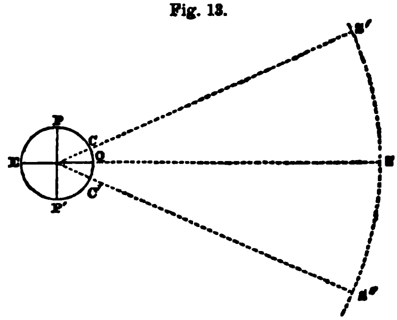
1. Latitude; a knowledge of which determines the angle of the sun's rays, and the respective lengths of day and night at opposite seasons.
2. Height above the sea-level.
3. Distance from the ocean.

There are many other things to be considered, in the endeavours to account for the special features of climate in the case of any given region, but the three here named are of vastly superior importance to any others, and too much attention can hardly be bestowed on their thorough comprehension.

1. The hottest parts of the globe are those upon which the rays of the sun descend vertically. This is the case only within the torrid zones, that is, through a belt of the globe

which is 47° across, or 23½° on either side of the equator, and which is marked on either hand by the lines of the summer and winter tropics. Within this zone the sun is always vertically over some point or other at the hour of noon—at which time the sun's place in the heavens is highest. Between the tropics and the poles, the sun, even at mid-day, is never vertical, and the amount of difference between the sun's place in the heavens and the place of a point directly over the head of an observer becomes greater with every successive parallel. The amount of this difference, too, becomes greater or less, for the time being, according as the sun's place is to the north or south of the equator—that is, according as the season of summer or winter prevails in either hemisphere. The subjoined diagram illustrates this—

Fig. 13.



Supposing the line P P′ to represent the earth's axis, and the points C C′, in either hemisphere, the place of the tropics, the annual range of the solar path in the heavens, in the direction of latitude (or declination), will be represented by the arc S′ S″. Within some portion or other of the terrestrial zone C C′, the mid-day sun will always be vertical. The point S represents the sun's place at the time of the equinoxes,* or when the sun is directly over the equator: S′ is the sun's place at the time of the summer solstice (*i.e.*, the summer of the northern hemisphere): S″ his place at the winter solstice. But in those parts of the earth which are within the arcs C P, C′ P′, or within the temperate and frigid zones, the sun's rays are at no time vertical, and the difference

* See page 8.

between their angle of contact with the earth and a perpendicular line becomes greater with every degree of latitude. The height of the mid-day sun, at any given locality, is determined by the place of the sun in the heavens, for the time being, either on the same side of the equator as the place itself, or on the opposite side. Within the tropics, the amount of this difference constitutes an item of much less consideration than within the temperate zones, and it is of less importance in the case of the latter than in the instance of the frigid zones. The summer and winter of the temperate and frigid regions, as we have seen, are the result of the sun's place in north or south declination, and the difference between the temperature of those seasons is vastly greater within the frigid zones than elsewhere. For a distance of 23½° round either pole, indeed, the sun is alternately above or below the horizon for periods which increase from twenty-four hours to half the year in duration.*

The amount of direct heat communicated by the sun is greatest when received immediately from overhead, and it becomes less and less according as it reaches objects in a direction more and more oblique. A large amount of this heat is, under this latter condition, lost in the transmission, by dispersion amongst the atmospheric medium through which it has to pass. The difference we daily experience between the heat of a noonday sun, and that derived from the slant beams of a morning or evening sun, illustrates this truth; and the difference between the heat communicated by the sun of our midsummer and midwinter skies is another example of it.

The *mean* temperature of any place is the average of the heat experienced throughout the year, as determined by observations made at frequent intervals during every day of the year. Similarly, the mean seasonal heat is the average of the observations made during any given season. Latitude determines the amount of this, in so far as the direct measure of solar heat communicated to the earth's surface is concerned—other conditions being, for the present, disregarded. The hottest parts of the globe are those within the torrid zone, and the amount of mean yearly heat gradually decreases from the equator towards the poles, the regions within the polar circles being the coldest parts of the globe.

The respective length of the day and night at opposite sea-

* Chap I., pages 5 to 10.

sons becomes an element of increasing importance in the determination of climate with every advance in the direction of the poles. Within the tropics, it is comparatively unimportant. At the equator, day and night are uniformly of twelve hours' duration, and in no part of the torrid zone does the excess above this period at one season of the year, or the amount short of it at the opposite season, exceed seventy minutes. At the tropic, the longest day is little more than thirteen hours, and the shortest nearly eleven hours. But in the latitude of London (50½°) the longest day is nearly seventeen hours in duration, and the shortest only seven hours. Under the arctic circle, the longest day is of exactly 24 hours' duration, the sun at the period of the summer solstice remaining above the horizon for the whole of that period, while the winter solstice exhibits a night of correspondent length. Within the polar circles, again, there are alternate periods of continuous sunshine, or continuous darkness, which increase in measure from twenty-four hours to six months, as the place of the pole is reached.

During the whole time that the sun is above the horizon at any place, his rays are communicating heat to the earth, while during the whole period of darkness the ground is parting (by the process of radiation) with the heat which it had previously possessed. Hence, within high latitudes, the long days and short nights of one season, and the short days and lengthened periods of darkness of the opposite season, involve extremes of heat and cold which are unknown to other localities, and which become increasingly marked with increasing proximity to the poles. During the long day of the polar summer, (a season brief in the total as compared with the entire year, but marked by a duration of continuous sunshine which has no parallel elsewhere,) there is an accumulation of heat which explains the high temperature of arctic lands in the months of July and August; as the lengthened absence of the sun at an opposite period of the year accounts for the extreme cold of an arctic winter.

The importance of the respective lengths of day and night at opposite seasons, in the determination of climate, is recognised in the scheme adopted by the geographers of antiquity, who divided the earth's surface into a series of climates,* regulated by the increasing length of the longest day. Between the equator and the polar circle, there were twenty-four such

* *Greek*, klima, a region, or climate.

climates, in each of which the length of the longest day exceeded by half-an-hour the length of the similar period in the adjoining zone. The breadth of these zones shows a continual increase from the equator towards higher latitudes. Between the polar circle and the pole, there are six similar climates, which, however, differ in the length of the longest day by periods of a month.

Latitude then serves as the first and chief measure of climate, in regard alike to the mean temperature of the year, and the extreme temperature of the respective seasons. Places experience a less amount of heat, on the average of the year, in proportion as they are within higher parallels of latitude—that is, the temperature undergoes progressive diminution from the equator towards the poles. The range of annual temperature, or extreme amount of difference between the heat of summer and the cold of winter, increases in the same direction.

The torrid zone is a region of great heat throughout the year, and with comparatively little difference (in so far as temperature alone is considered) between opposite seasons.

The temperate zones are regions of decreasing heat, on the average of the year, but with an increasing range of seasonal temperature, the difference between the extremes of summer and winter becoming more and more marked with increasing distance from the tropics.

The frigid zones are regions of low temperature on the average of the entire year, and of excessive winter cold, contrasted by a brief season of extreme summer heat.

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2. *Height above the sea.*—Of the secondary causes which determine climate, the most important is—comparative elevation. The temperature of the air falls with increasing altitude above the mean level of the earth's surface, and a degree of cold which is below the freezing point may be reached, in every part of the globe, by an ascent of a few thousand feet. This decrease of temperature does not maintain a strictly

uniform ratio, but its average rate—at least within the lower regions of the atmosphere—is about 1° (of Fahrenheit's thermometer) for every 240 feet of ascent. The traveller who climbs a lofty mountain-range, or mounts the sloping side of a high plateau, passes from the warm temperature of the lowland plain or sheltered valley through successive degrees of increasing cold, until he at length reaches a region of unmelting snow and eternal frost.

The height of the snow-line (as the commencement of the snowy region is called) varies with the latitude. Some examples of this have been given in a preceding page.* In the equatorial Andes, it is not found until an altitude of 15,800 feet has been reached. In the Alps, it occurs at 9000 feet, and in the mountains of Scandinavia at less than half that elevation. Below the line of unmelting snow, there is also, in the case of most mountain-ranges, a region of winter snows only, the thawing of which, with the return of a summer sun, contributes largely to swell the beds of the torrents which abound in mountain-lands. This zone between the snow-lines of winter and summer coincides, in the Alps, with the upper portion of the glacier-region.

The position and general configuration of any extensive mass of land, as well as its mere elevation, affect its temperature in a large degree. The snow-line is higher on the northern face of the Himalaya, towards the plateau of Tibet, than on the southern slope of the mountains,—a seeming anomaly, but one which is of easy explanation. The Himalaya and adjacent plateaus, like all elevated mountain-lands, constitute a great region of condensation. The moist vapours with which the prevailing winds of that region are laden—derived in their passage across the Indian Ocean—arrive first at the southern face of the mountain-chain, and are there stripped, by the process of condensation, of the chief part of their contained moisture. Hence the deposit of snow upon the southern face of the mountains greatly exceeds that which falls upon their northward slopes, and it descends to correspondently lower levels.† Radiation from the surface of an elevated table-land perhaps tends in some measure to increase the height of the snow-line upon mountain slopes by which it is immediately bordered.

Regions of elevation, in whatever latitude, have therefore a

* See pages 37-45.

† Strachey: Journal of Royal Geographical Society, vol. xxi., p. --

temperature which is lower, by many degrees, than that of less elevated lands under similar parallels. Such regions as Tibet, Afghanistan, Armenia, Central Spain, Mexico, Quito, and many others, are examples of this upon a large scale ; as tracts of ground of even very moderate size—familiar, in numerous cases, to our personal experience—are on a smaller scale. The climate of Quito, though nearly under the line of the equator, is that of the temperate zone; but then Quito is at a level of 9000 feet above the sea. Tibet experiences a low temperature, though within the same parallels as the Mediterranean coasts ; but the plains of Tibet are fifteen thousand feet above the level of the sea, an elevation nearly as great as that of the summit of Mont Blanc. Mexico exhibits, under the same parallel, three distinct zones of climate,—the heated lowland, along the coast of the Mexican Gulf ; the cool temperature of the mountain side, from the plain upward to heights of 4000 or 5000 feet ; and the still lower temperature which belongs to the summit of the interior table-land, at altitudes of from five to nine thousand feet.

Again, plateau-regions are exposed, at least within extra-tropical latitudes, to much greater extremes of temperature, at opposite seasons, than are experienced by lands of opposite conformation. Their high and unsheltered elevations experience alternately the scorching heat of a summer's sun, and the piercing blasts of winter, which sweep over their generally naked surface. The interior of Spain supplies an eminent example of this ; the Spanish capital is in summer one of the hottest, and at the opposite season one of the coldest, of European cities. Its mean summer and winter temperatures exhibit a difference of 33°, while the correspondent range of the summer and winter temperatures of Lisbon, at a direct distance of only 300 miles, and differing in latitude by less than two degrees, is little more than 18°. The table-lands of Western Asia supply yet more striking examples. At Teheran, the Persian capital, the power of the summer sun is so intense that flowers blow and wither in a single day. At Furrah, in Afghanistan, says Ferrier, the mid-day heat of summer makes eggs hard, and balls of lead malleable. Again, Erzeroom, the chief city of Turkish Armenia, seated in the midst of a plain which is 6000 feet above the sea, has a summer of tropical heat, and a winter which parallels in severity that of the polar regions.

3. *Position with regard to the sea.*—The ocean is a great moderator of heat and cold. Water, as we have elsewhere said, preserves a more equable temperature than land; it becomes less heated by the sun's rays during the hours of daylight, and less cooled below the average when the sun's rays are withdrawn.* This equability of temperature is communicated to the air with which any large body of water is in contact, and thence to that which is over the adjacent land. Islands, and maritime countries in general, are hence, for the most part, free from the extremes of heat and cold which often characterise inland regions.

Every division of the globe furnishes examples of the superiority of climatic condition which results from proximity to the sea, and to the wide contrast which obtains between the phenomena of meteorology in the instance of countries so situated, and those that are experienced in the case of tracts that lie far inland. The climate of Britain, and that of the correspondent latitudes of European Russia, supply one of the most striking of such instances. Edinburgh is in almost the same latitude as Moscow, but while the average temperatures of the summer and winter quarters are at Edinburgh respectively 57° and 38°, the correspondent temperatures of the same seasons as experienced at the old Muscovite capital are 64° and 15°. At Moscow, there is a difference of nearly 49° between the mean temperature of summer and the mean of winter; while at Edinburgh the equivalent difference is less than 19°. If instead of the mean seasonal temperatures, we take the maximum temperatures—that is, the *extremes* of heat and cold at each locality—the difference is still more in favour of the Scotch metropolis. Who does not recognise, at a glance, the vast superiority of a climate in which the range of heat and cold is preserved within the moderate limits which are familiar to the inhabitants of Britain, as compared with that under which the vast plains of Russia are annually burnt up, or converted, for months together, into a pathless wilderness of snow? Who

* Hence, among other results, the belief popularly entertained of certain springs, that they are colder in summer and warmer in winter. "The fount that ran by Ammon's shade," (the well-known fountain of the Sun, in the North African desert,) is one of the number. In reality, springs which derive their water from any considerable depth preserve the same, or very nearly the same temperature, throughout the year, while the temperature of their place of issue undergoes considerable variation. *Relatively* to the air, they are therefore colder in summer, and warmer at the opposite season.

does not see the numerous train of consequences which must result from such differences, in regard to habits of life, dress, amusements, and social usage of every kind? Yet more, what reader of history will fail to recall the vicissitudes of fortune, affecting the fate of empires, which have derived their colouring from the terrible severities that belong to the climate of the Russian plain? The fate of the Swedish conqueror's * army in 1709, and the yet more terrible fate of a greater conqueror's invading army upwards of a century later,† tell the same story of suffering, and illustrate the same lesson in respect of the truths of Physical Geography.

One of the ablest of our geologists has shown that the question of the relative distribution of land and sea is the basis of all inquiry respecting the conditions of climate, alike in former eras as in the present chapter of the world's history.‡ If the lands of the earth, instead of being distributed as they actually are, were differently grouped, the whole temperature of the globe's surface would exhibit a different result. If the whole mass of land were grouped within regions proximate to the equator, intense heat would be the result, and the greater part of the globe would be uninhabitable by man. On the other hand, were the whole of the lands grouped in great masses around the poles, an opposite result would ensue, and mankind would be uniformly degraded to the condition of the Esquimaux or the Samoiede. Large continuous masses of land become, under a tropical sky, regions of excessive heat, and their burning temperature influences the movements and other conditions of the atmosphere for vast distances around. The Sahara of the African continent is a vast natural furnace, the influences of which affects the climate of lands that are a thousand miles away. Happily, the Mediterranean sea intervenes to protect Europe from its worst results. Were the Mediterranean occupied by solid land, what is now southern Europe would be converted into an arid waste, and the smiling shores of Greece and Italy become parched as the regions that form the border of the desert.

The climates of Central Asia repeat the same story of excessive heat and cold, consequent upon removal by vast spaces from the tempering influences of the ocean. There are but

* Charles XII., at Pultowa.
† Napoleon I., in the Russian Campaign of 1812-13.
‡ Sir Charles Lyell: Principles of Geology.

two seasons in Mongolia—nine months winter, and three months summer. "In the deserts of Tartary," says Huc, "and especially in the country of the Khalkas, the cold is so terrible, that during a great part of the winter the mercury freezes in the thermometer; and often when the earth is covered with snow, and the north-west wind begins to blow, it drives the avalanches before it, till the whole plain looks like a great white stormy ocean."

Eastern Russia, Mongolia, Africa, interior Australia, with many other localities, furnish examples of *continental* climates, which are climates of extreme heat and extreme cold. Great Britain supplies an example of *insular* climate, which is a climate of moderate degrees of heat and cold—of summers which are never intense in their heat, and winters which never reach the excessive cold felt in other lands. New Zealand, and, in yet higher measure, Tasmania, display, in the southern hemisphere, similar conditions of comparatively uniform temperature.

For further examples of insular and maritime climate, we might point to the tracts of land that are found distributed over the waters of the great ocean, within either half of the globe. Nowhere are the advantages of equable temperature more strikingly exhibited than in the case of the South Sea Islands, as the island-groups of the vast Pacific are often called. Polynesia exhibits, within the border of the torrid zone, a climate which is a perpetual spring—the warm spring of the tropics. The thermometer seldom varies more than five or six degrees throughout the year. The heat which ordinarily characterises tropical latitudes is unknown. The breezes from the surrounding sea diffuse a perennial freshness through the air. A succession of fruits and flowers display, throughout the year, the abundant gifts of nature, and everything—save man—realises the attributes of an earthly paradise!

Among minor causes which affect climate, and contribute to regulate its conditions in particular localities, the following may be enumerated:—The direction of mountain-chains, (or, in their absence, the general slope of the land;) the nature of the soil; the direction of prevailing winds; and, in the case of

maritime countries, the course and temperature of currents. The extent to which the soil has been brought under culture is another of the elements which materially affects the temperature of any particular district. The draining of marshes, and cutting down of forests, which are necessary preliminaries to the use of the plough, tend in most cases to raise the temperature, as well as to improve it in other regards. The winters of central Europe are less severe now than in ancient times, when almost unbroken forests stretched from the skirts of the Alps to the plains bordering upon the Baltic, and the great rivers stagnated in their lower courses through vast swamps, which have long since given way before the labours of the engineer. Our own country has shared in this general amelioration of one of the most important of its physical conditions. The alternate wastes of moor, forest, and fen, which once spread over two-thirds of the surface of Great Britain have been replaced by the corn-field or the green meadow-land, and as the upturned soil has been exposed to the influence of the sun, and the air allowed to circulate freely through tracts which were formerly darkened by the deep shade of forest growth, the air has been rendered both warmer and drier than it formerly was.

The influence of mountain-chains upon the climate of adjacent lands is at once obvious. In the case of those which lie in the direction of east and west, the opposite sides of the range receive the rays of the sun at different angles of elevation, and receive the direct solar heat in different measure. The northern and southern slopes of the Alps, and the difference between the climate of Switzerland and that of Lombardy, furnish the tritest of examples. Upon one side is the region of the glacier and the avalanche; on the other, that of the corn-field, olive-ground, and the mulberry-plantation. In the one case the snow-line is found at an altitude of 8000 feet above the sea, in the other it recedes to upwards of 9000 feet. But this instance, so often referred to, is not seldom misunderstood. If the Alps, as is often said, shelter Italy from the cold winds of more northerly European latitudes, the cold currents of air which are generated among the higher elevations of the mountain-region sweep at times with piercing severity over the plains below, and the winter of Piedmont and Lombardy is often one of great severity.

The general slope of the land, in the case of any particular country or district, furnishes an example on a large scale of

that which every field or garden illustrates upon a scale of smaller proportions. A western or a southern slope offers, in the case of our own country, more genial conditions of temperature, and consequently greater facilities of ripening culture, than an inclination towards opposite quarters of the sky. This is equally true of a county or a province as of a flower-garden or an orchard. The slope of a country is at once marked out upon the map by the direction of its rivers. Thus, in the case of the larger part of Britain, we observe a general slope to the eastward, for the greater number of our rivers discharge into the North Sea. The comparatively low temperature of our eastern coasts, and their exposure to winds blowing from eastern quarters of the sky, are the well-known attributes of that division of the island. The higher grounds which line our western shores, and the lands which slope from them towards the Atlantic waves, enjoy a warmer (as well as a moister) air. The river-basins of France exhibit, with one exception, a general westwardly inclination. The basin of the Rhone, directed to the southward, is under yet more favourable conditions in this regard. It is the true region of the olive and the mulberry, while the orange, ripening in the open air, gives evidence of the high temperature which distinguishes the maritime division of the ancient Provence. The valley of the Danube, with its general eastwardly slope, displays—especially in its lower portion—conditions of temperature which are much less favourable than those of the Rhine, though the course of the latter river lies under parallels which are several degrees further north.

Among the secondary causes affecting climate, probably none is of greater importance than the direction of prevailing winds. The currents of air are warm or cold, wet or dry, according as they have had their origin in warm or cold latitudes, and have traversed inland tracts, or the expanse of ocean, in their advancing course. With us, and in the northern half of the globe in general, north and east winds are cold and dry, while south and west winds are warm, and often accompanied by moisture. Within the southern hemisphere, these conditions are reversed, and the hottest currents of air come from a northwardly direction. The prevailing winds of western Europe are from the west and south-west; and it is to this fact that we must mainly ascribe the high winter-temperature, as well as the comparative freedom from extrem

of heat and cold, which distinguishes the countries of western Europe. The same cause explains the abundant moisture which belongs to those regions in general, and which distinguishes the western shores of our own islands in a remarkable degree. Such winds have traversed the immense expanse of the Atlantic, and come to the western seaboard of Europe laden with the moist vapours gathered on their course. These vapours, condensed upon the high grounds which line the western side of the British Islands, or, further to the northward, upon the long chain of the Scandinavian mountains, fall to the earth in copious torrents of rain. In the process of condensation, a vast quantity of latent heat is disengaged, and the temperature is correspondently raised. Warmth and moisture are, indeed, speaking generally, concomitant conditions of European climate, and are especially so in the case of western Europe.*

Even in the case of lands which nearly approach the tropic, the influence of prevailing winds in raising or lowering the temperature is strikingly seen. At New Orleans, bordering on the Mexican Gulf, and throughout the adjacent states of the American Union, the winters are often of excessive severity. Cold winds, generated in the higher latitudes of the New World, and blowing for weeks in succession from the northern quarter of the sky, are the cause of this. The generally level interior of the North American continent —a vast lowland plain, bounded only to the east and west by the Alleghanies and the Rocky Mountains—presents no obstacle to the advance of these cold northerly blasts. The middle and eastwardly parts of North America are subject to like influences, in this regard, to the plains of eastern Europe. To the westward of the Rocky Mountains, on the other hand, the conditions affecting climate present greater analogy to those that belong to western Europe.

* "The Pyrenees, the Alps, and the German as well as the Scandinavian mountains," (says Hopkins,) "have their degrees of influence in condensing vapours brought from the Atlantic, and, by the vacua created about them, drawing further supplies to render western Europe, especially in the parts near the sea, warm in winter. Each locality in this part of the world is, in the cold season, warmed in proportion to the amount of vapour condensed in it. The thickly-shrouded and drizzling atmosphere of the western islands of Scotland, in lat. 58°, constantly giving out heat from condensation, is warmer than that of London in the winter; but then, six times the quantity of rain has been known to fall in the former place than descended in the latter, and more rain has fallen in the Isle of Skye in the month of January than fell in Paris or London in the whole year."—(Journal of Royal Geographical Society, vol. 27.)

In the case of many countries, some local wind, of occasional prevalence, forms a marked characteristic of climate. The often-described *simoom* of the desert, an intensely-heated and dry wind, which raises the temperature like the blast of a furnace, and fills the air with particles of sand, of suffocating quality, is a familiar example. The *sirocco* of the Mediterranean shores is a wind of similar quality and origin, but moderated by passage across the great inland water. The *harmattan* of Senegambia and Guinea is a cold and intensely dry wind, which blows from the north-east, during the months of December and January. The *mistral* of southern France possesses similar qualities to the last-named wind, and blows, for days together, down the valley of the Rhone.

Winds transport particles of dust, and, with them, the minuter forms of vegetable and animal life, to vast distances. The phenomena known to sailors as red fogs and sea-dust are evidence of this. In the Mediterranean, and also in the neighbourhood of the Cape Verde Islands, showers of dust, of brick-red or cinnamon colour, are sometimes experienced, in such quantity as to cover the sails and rigging, hundred of miles away from land. Amongst this sea-dust, examination with the microscope has detected infusoria and other organisms native to the tropical regions of South America.

The influence of oceanic currents upon climate, in the case of maritime countries, is not without importance. A current of warm water tends to impart warmth to the superjacent and immediately adjoining air, and a cold current the reverse. But this influence, as a cause of perennial mean temperature, has probably been greatly exaggerated. The warm temperature of western Europe has been very commonly ascribed to the influence of the Gulf Stream, without any distinct proof that the water of the Gulf Stream ever reaches the European sea-board. The cold current from Baffin Bay, flowing immediately along the eastern coasts of North America, perhaps accounts in some measure for the low temperature of that region, as compared with correspondent parallels on the opposite side of the Atlantic.

The greater or less quantity of *rain* in any region is a highly-important element of its climate. Rain is unequally distributed over the surface of the earth, both as to quantity and as to the seasons of its occurrence. There are parts of the world which are altogether rainless, as there are others whi-

possess a superabundant moisture. As general rules, the three following conditions hold good :—

1. Rain is more abundant in warm than in cold countries—*i.e.*, its quantity decreases from the equator towards the poles.
2. Rain is more abundant in maritime tracts than in inland regions.
3. Rain is more abundant in hilly districts and mountain-regions than in lowland regions.

On the whole, more rain falls in the western hemisphere than in the eastern half of the globe. This naturally results from the fact that the western includes a much larger proportion of water than the eastern hemisphere.* The eastern half of the globe is continental, the western chiefly oceanic. It is from the ocean that all rain is primarily, by process of evaporation, derived. Clouds are masses of aqueous vapour, drawn in greatest abundance from those regions where a heated atmosphere, acting upon the expanse of water beneath, most facilitates evaporation—that is, from the regions of tropical heat. The quantity of moisture which air is capable of holding in suspension increases with its temperature. That is, warm air can contain, in the form of aqueous vapour, a greater amount of water than the same body of air at a lower temperature is capable of holding. If air, at any given temperature, and saturated with moisture, becomes exposed to any cooling influence, so that its temperature is lowered, condensation ensues. The aqueous vapour becomes reconverted into water —or, in very low temperatures, into snow or hail.

If two bodies of air, possessing different temperatures, but each charged with water up to the point of saturation, come into contact, so as to mingle with one another, rain is produced; for the resultant temperature of the whole becomes lower than the point at which saturation, without precipitation, can be maintained. Winds effect a continual transfer of portions of the atmosphere from one region to another, and bring rain or drought according as they have traversed vapour-yielding surfaces or otherwise—that is, as they have passed over great expanses of ocean or of land. In greater or less degree, according to their elevation and consequent temperature, all mountain-regions are regions of condensation.

* Page 12.

That face of a mountain-region towards which the course of prevailing and moisture-laden winds is directed, receives consequently copious floods of rain, while the opposite face of the same chain is often parched and arid. The abundant rains of Norway are derived from the winds which blow from the neighbouring Atlantic Ocean, and have their contained vapours condensed upon the western face of the Scandinavian mountain-chain. In like manner, the south-west monsoon, which blows, during six months of the year, upon the Malabar coast of India, comes densely laden with the moist vapours of the Indian Ocean. The long chain of the Ghauts arrests its progress; condensation ensues, and copious floods of rain are poured upon the seaward face of the mountain region. Exhausted of its moisture, the same wind, or such portion of it as passes the mountain-crest, only reaches the opposite side of the chain as a dry wind. Along the line of the Coromandel coast, on the other hand, the north-east monsoon is accompanied by rain.

The maximum fall of rain in hilly regions appears from observation to occur within definite limits of elevation, coincident, as might be expected, with those which mark the ordinary altitude of the rain-clouds. Within warm latitudes, the greatest amount of rain-fall is found at heights between three and five thousand feet above the sea. Above these heights, the quantity becomes lessened.

In those parts of the globe where the atmospheric currents, or winds, are either constant or of periodical recurrence—that is, within or near the tropics—the seasons of rain are fixed and unvariable. The year is divided between a dry season and a rainy season. In the former, the sky is unclouded during months together, and the parched ground exhibits all the effects of intense heat, combined with drought. In the latter, the rains fall, for a time, in abundant torrents, with a violence to which the cooler regions of the globe offer no parallel. There are fewer rainy days in the year in warm than in cold countries, but a vastly greater abundance of rain falls within the shorter time than is precipitated during the whole year within higher latitudes. All the phenomena of atmospheric change are exhibited on a scale of greater intensity within the tropics. Thunder-storms are experienced there on a scale of surpassing grandeur, and are accompanied by floods of rain, which, descending in sheets, within a few hours lay whole tracts of country under water, and convert

what is at ordinary times the dry bed of a rivulet into a raging torrent. In some regions (as in the West Indies) there are two wet and two dry seasons annually, as the sun passes and repasses the zenith in his annual path.

Within the tropics, the rains follow the course of the sun—that is, the season of rain coincides, upon either side of the equator, with the period of the sun's highest declination. In the northern half of the torrid zone, the period between September and March is the season of dry atmosphere and unclouded skies; as the sun passes the equinox and approaches daily nearer to the zenith, clouds attend his course, and a rainy season (of longer or shorter duration, in particular localities) succeeds. To the southward of the equator, the dry season embraces from April to October inclusive, and the tropical rains fall within the opposite half of the year. The limit of tropical rains, however, does not in all cases precisely coincide with the astronomical boundaries of the torrid zone, though nowhere passing it by more than a few degrees.

In the case of extra-tropical regions, the seasonal distribution of rain follows an opposite law, the period of greatest rain being for the most part coincident with the winter months of the year. But it is only within the warmer latitudes of the temperate zones (or in sub-tropical latitudes, as they are called,) that the rains are limited, with any strictness, to particular seasons. Elsewhere, rain is more generally distributed throughout the year, though more abundant in some months than in others. The countries of southern Europe, and those bordering the Mediterranean in general, are regions of winter rain, while western Europe is distinguished rather by the abundance of autumnal rains.

The total annual rain-fall is said to average 77 inches within the tropical regions of the Old World, and 115 inches in the correspondent latitudes of America.* The annual rain-fall at a few well-known localities is given, for the sake of comparison, in the following Table — the places being arranged according to their position in the eastern or western hemisphere, and in the order of their distance from the equator:—

* Guyot: Earth and Man.

WESTERN HEMISPHERE.

Place	Latitude	Inches of rain.
Maranhao (Brazil)..	S. lat. 2° 30′	276
Paramaribo, (Dutch Guiana)..........	N. lat. 5° 45′	229
Island of Granada, (W. Indies)......	N. lat. 12° 8′	126
Kingston, (Jamaica)	N. lat. 18° 0′	83
St Domingo..........	N. lat. 18° 29′	107
Vera Cruz............	N. lat. 19° 15′	60
Rio Janeiro...........	S. lat. 22° 50′	59
Havanna..............	N. lat. 23° 8′	97
New Orleans.........	N. lat. 29° 57′	52
Charleston, (U. S.)	N. lat. 32° 50′	48
Washington..........	N. lat. 38° 53′	35
Philadelphia.........	N. lat. 39° 57′	47
New York............	N. lat. 40° 43′	36
Toronto...............	N. lat. 43° 40′	39
Sitka..................	N. lat. 57° 34′	88

EASTERN HEMISPHERE.

Place	Latitude	Inches of rain.
Singapore...........	N. lat. 1° 16′	97
Madras..............	N. lat. 13° 5′	48
Mahabaleshwar...	N lat. 17° 59′	302*
Bombay.............	N. lat. 18° 57′	80
Calcutta.............	N. lat. 22° 34′	81
Sydney...............	S. lat. 33° 51′	52
Adelaide.............	S. lat. 34° 35′	22
Melbourne..........	S. lat. 38° 18′	31
Rome.................	N. lat. 41° 53′	39
Paris..................	N. lat. 48° 49′	21
Plymouth...........	N. lat. 50° 23′	37
London..............	N. lat. 51° 30′	24
Liverpool...........	N. lat. 53° 24′	34
Kendal...............	N lat. 54° 20′	56
Edinburgh..........	N. lat. 55° 57′	24
St Petersburgh....	N. lat. 60° 0′	16
Bergen...............	N. lat. 60° 24′	82

The torrid zone includes the regions of most abundant rain-fall: in some localities, as Brazil and other parts of tropical America, the immediate neighbourhood of the equator is the seat of almost constant precipitation, the rain rarely intermitting for any period of lengthened duration. Brazil, Guiana, the islands of the West Indies, Central America, and the shores of the Mexican Gulf, in the New World,—the coasts of Guinea and Senegambia, with those of eastern Africa, India, and the islands of the East Indies, in the Old World, are among the regions of most abundant rain-fall: all of them fall within the zone of tropical rains. The coasts of eastern Africa, India, and southern China, fall within the region of the monsoon rains.

The interior plains of the Old World, on the other hand, are distinguished by the opposite characteristic. A vast and nearly rainless region stretches through the continents of Africa and Asia, between the meridian of 16° west and 118° east of Greenwich, and varying from the 15th to the 47th parallel. This broad zone of arid lands comprehends the vast expanse of the African sahara, with the extensive deserts of interior Arabia, Persia, and Mongolia. Though not—excepting in the worst portions of the Sahara—absolutely rain-

* Mahabaleshwar is a station within the Ghauts, to the southward of Bombay, and at an elevation of 4500 feet above the sea. According to Dr Buist, (Bombay Geographical Society,) this extraordinary amount of rain-fall i- more than doubled at Cherrapoonjee, (lat. 25° 14′, long. 91° 45′,) a statior the Cossya Hill, to the north-eastward of Calcutta. The average fall at place is said to be 610 inches, above 20 feet occasionally falling in the mor June alone! Cherrapoonjee lies at an elevation of 4200 feet above the s

less, yet rain only occurs at uncertain and distant intervals, frequently of several years apart, and intense aridity is the distinguishing feature of the whole region. Within the African and Arabian wilderness, indeed, the intense heat of the air causes it to absorb at once whatever of moisture may be derived from adjacent lands or seas, and the few light clouds which are occasionally seen over its burning expanse rapidly disappear—dried up, as it were, even while the expectant wayfarer gazes upon them.

There are like rainless—or almost rainless—districts in the New World, though of much smaller extent. Some of the interior plains of the Mexican plateau are distinguished by intense aridity, though the maritime portions of that country exhibit an excessive rainfall. But the most remarkable of such tracts in the western half of the globe is found to the southward of the equator, embracing the coast-district of Peru and Bolivia, between the parallels of 4° and 27°. This range of country stretches along the western base of the Andes, between those mountains and the Pacific Ocean. The tract known as the Desert of Atacamá falls within its limits. Throughout this extensive range of coast, it is only at rare intervals that a drop of rain refreshes the thirsty soil, the sole moisture being derived from dense mists (or *garuas*) which occur at certain seasons. Yet the eastern face of the Andes, within the same parallels, is watered by copious rains. The explanation of this, as of so many other conditions of local climate, is found in the direction of the prevailing winds. The currents of air which bring abundance of moisture, and consequent luxuriance of vegetable life, to the Brazilian plains, are the trade-winds of the southern Atlantic, laden with the moist vapours drawn up in their passage over its extensive basin. The high and cold summits of the Andes arrest their further progress to the westward, and condensation ensues; hence the copious floods of rain which are poured down upon one side of the mountain-region, while the other side experiences comparative aridity.

ISOTHERMAL LINES.—The varying conditions of climate, and the diverse causes to which these varieties are due, assume their most obvious manifestation when places which have correspondent temperatures are connected upon a map by means

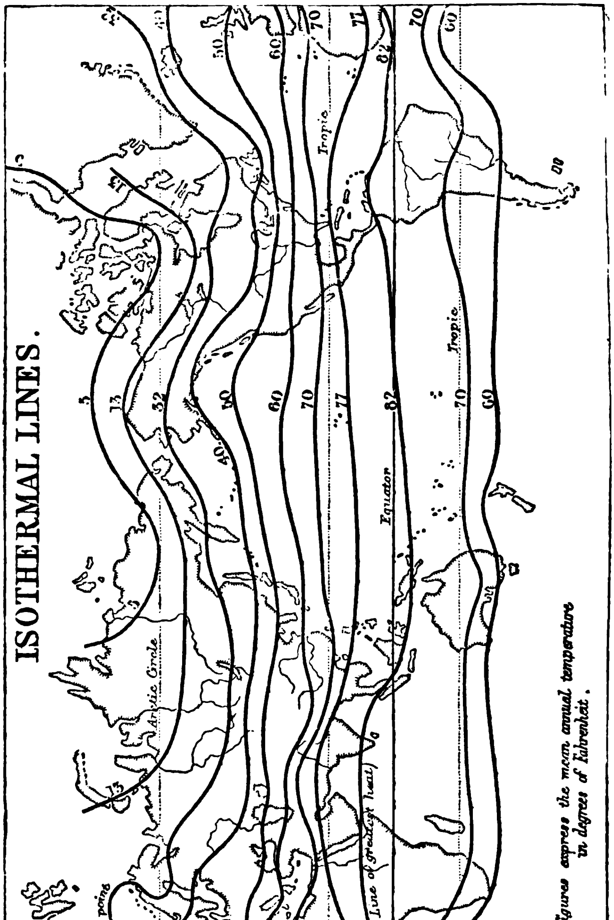
of lines drawn so as to pass through them. Such lines are called isotherms—that is, lines of equal heat.*

If temperature were regulated solely by latitude, it is obvious that all places at similar distances from the equator would enjoy like degrees of heat, and, if such were the case, the parallels of latitude drawn upon our maps and globes would constitute isothermal lines. But this is by no means the case. On the contrary—and for reasons sufficiently explained in the preceding pages—places at correspondent distances from the equator exhibit, in numerous instances, widely different conditions of climate. Hence lines drawn through places of like temperature often deviate widely from the direction of parallels of latitude. This deviation, inconsiderable within the torrid zone, becomes greater with every further degree of advance in the direction of the poles. It is nowhere more widely marked than in the case of places lying upon opposite sides of the Atlantic Ocean, within the limits of the north temperate zone.

The western coasts of Europe have throughout a higher average temperature than the eastern coasts of the New World. Lines drawn through places of correspondent temperatures in western Europe and the eastern seaboard of North America, range therefore some degrees nearer the pole in the case of the former than the latter of those localities. The mear yearly temperature of Lisbon (61·4,) in lat. 38° 42′, is only four and a half degrees lower than that of Charleston, in South Carolina, which is six degrees nearer the equator. London, in lat. 51° 30′, has a mean annual temperature of 50·8, which is the same as that of Philadelphia, though the latter place is more than eleven degrees nearer the equator. Edinburgh, nearly under the 56th parallel, has a mean yearly temperature of 47, which is seven degrees higher than that of Halifax, in Nova Scotia, though the latter place lies upwards of ten degrees further to the southward. And Copenhagen, in lat. 55° 41′, with a mean yearly temperature of 46·5, is above eight degrees warmer than St John, Newfoundland, though the latter place is more than eight degrees further removed from the pole. Numerous other instances might be quoted.

Places which enjoy correspondent mean temperatures, taking *the average of the entire year*, often exhibit, however, widely different conditions of climate, even in respect of

* *Greek*—isos, equal—thermē, heat.



ISOTHERMAL LINES.

The figures express the mean annual temperature in degrees of Fahrenheit.

temperature only. In one case, the mean may be the result of a comparatively equal distribution of heat throughout the year—that is, of moderate summers and correspondently mild winters ; in the other, the same mean may result from excessive heat at the one season, balanced by extreme cold at the opposite period of the year—that is, from summers of excessive heat, and winters of extreme cold. Isothermal lines may of course be drawn through places of correspondent summer or winter temperatures.* Such lines, which are sometimes marked upon maps, exhibit in many cases a deviation from the direction of parallels which is even greater than that shown by isotherms of mean yearly heat. Similar lines indicative of the mean temperature for each month of the year are drawn upon the elaborate maps of Professor Dové, and exhibit the result of a vast number of observations, collected from upwards of eight hundred different stations, scattered at wide distances apart over the face of the globe.

A Map of the World upon which isotherms of mean yearly temperature are drawn illustrates strikingly the truth, that, within the temperate and frigid zones of the northern hemisphere, the western side of either continent is warmer by many degrees than its eastern side. The mean temperature both of the Old and New Worlds gradually diminishes with progressive advance to the eastward. Hence the isotherms, when prolonged round the entire circuit of the globe, within the zones referred to, assume in some parts a convex, and in others a concave shape. In other words, they rise to high latitudes upon the western side of Europe and North America, and, sinking in the direction of the equator as they traverse the continents of the Old and New Worlds to the eastward, reach their lowest points as they respectively approach the eastern limits of Asia and North America. Pekin, the capital of China, has a mean temperature almost identical with that of New York, with which it nearly corresponds in latitude. And, similarly, the western seaboard of North America exhibits a degree of heat which resembles that enjoyed by the coasts of Western Europe under correspondent parallels of latitude.

Furthermore, while the mean of yearly temperature is highest on the western side of either continent, and dimin-

* Isotherms of mean summer temperature are distinguished as isothermal lines—*Greek*, isos, equal, theros, summer ; those of mean winter temperature, as isochimenal lines (isos, equal, keima, winter.)

ishes to the eastward, the *extremes* of seasonal temperature become more strongly marked with advance in the same direction. That is, the western coasts of Europe and North America enjoy comparatively moderate summers and mild winters, while the plains of interior and eastern Asia, in the Old World, with the Atlantic seaboard of North America, in the western hemisphere, experience summers of intense heat and winters of excessive cold. The summer of New York is hotter than that of Algiers, and the winter colder than that of Copenhagen ; Montreal has a summer nearly as warm as Lisbon, and a winter as cold as Petersburg ; and Pekin possesses, in point of temperature, nearly the same summer as Cairo, with a winter as severe as that of Stockholm.

XI.

AGENTS OF CHANGE.

THE preceding chapters describe the natural aspect of the earth's surface, as it exists in the present day. But this condition undergoes continual change—in some cases, by stages so slow and gradual, and performed through agencies so little obvious to cursory observation, as to pass comparatively without notice; in others, by means of phenomena so violent, and attended with results so destructive and disastrous, as to constitute the most striking amongst the natural forces manifest in the external world. Such changes as are referred to may, for the most part, be classed under one or other of two great divisions—*aqueous* and *igneous;* according as they are due to the agency of water, or to that of fire.

AQUEOUS CHANGES.—We must refer to the works of professed writers on geology—and, particularly, to Sir Charles Lyell's admirable "Principles of Geology"—for a complete account of the various ways in which water constitutes an agent in effecting natural changes in the aspect of the earth's surface, and especially in the relative contour of land and sea at their line of contact. Some of such changes constitute agents of destruction—others of reproduction. In the former, there is a tendency for the ceaseless action of water to destroy the land, of which the undermining and consequent falling of cliffs upon certain parts of the coast, in the case of nearly all maritime countries, or the inundation of extensive tracts of land, offer the most familiar examples. In the latter, the same agent—running water—operates to fill up estuaries and harbours, or to add to the extent of land by means of the formation, at the mouths of rivers, of those tracts of alluvial soil known as *deltas.*

The eastern shores of the North Sea, between the mouths of the rivers Scheldt and Elbe—including the coasts of Holland and the neighbouring portions of Germany—offer some of the most prominent instances of destructive change, due to

the violent action of the sea. The immense gulf known as the Zuyder Zee, which measures between 40 and 50 miles in either direction, and is, in the present day, the scene of no inconsiderable amount of Dutch enterprise, was formed by irruptions of the sea during the thirteenth century. A portion of its site was anciently occupied by Lake Flevo, a body of inland water, fed by the inundation of the Rhine over the adjacent marshes. The sea burst, during successive periods of storm, over the adjacent lands, forming several channels of communication with the inland waters, which were at length widened into the present broad entrance of this extensive but shallow basin.

The whole line of the Dutch coast presents the evidence of similar changes, and the islands which extend from the Helder to the mouths of the Weser and the Elbe have undergone repeated alterations of form and size. The large gulfs known as the Dollart and the Iahde are of like origin to the Zuyder Zee. They owe their existence to inroads of the adjacent waters, and were progressively formed at various periods between the eleventh and the sixteenth centuries. The western coasts of Denmark have been similarly exposed to the ravages of the ocean. During a violent storm in 1825 the sea broke through the narrow isthmus by which the Liim Fiord (in the northern part of Jutland) was terminated to the westward, the waters of the North Sea thus forcing for themselves a communication with the channel of the Kattegat. The passage thus formed has since remained open.

But the industrious Dutchman of modern times has successfully opposed his skill to the further ravages of the ocean, and has gained from its waters more than he has lost. Large tracts of land have been recovered from the sea by means of drainage. In some parts of the Netherlands the land is actually on a lower level than the adjacent waters, and is only preserved from inundation by means of artificial mounds or dykes. Elsewhere, the required protection is supplied by the agency of natural means. From the channel of the Helder (the principal entrance to the Zuyder Zee) southward, the coast of the North Sea is protected by a broad line of sand-hills, or *dunes*, the features of which have been described in a preceding page.*

* History records a well-known occasion on which this peculiarity of physical conformation proved the means of salvation to the industrious citizens of the Low Countries. During the siege of Leyden, in 1573–4, when all other

The coasts of Britain exhibit, through the greater portion of their circuit, instances of change due to the action of tidal currents and waves. This change is sometimes attended by gain of land, but more frequently involves an opposite result, and the labours of the engineer are called into requisition for the purpose of checking the continual waste. Those portions of the English coast which lie between the high rock of Flamborough Head and the estuary of the Thames—embracing the low tract of Holderness, in the east riding of Yorkshire, with the coasts of Lincoln, Norfolk, Suffolk, and Essex—have been peculiarly the seat of such changes. The shores of Kent, Sussex, Hants, and Dorset, exhibit the action of like changes, in nearly equal degree. Throughout this extensive range of coast, the cliffs consist, for the most part, either of chalk, or of soft sands and clays, which yield readily to the erosive action of water. Nearer the entrance of the Channel, the cliffs of Devon and Cornwall, which are composed chiefly of harder rocks, decay less rapidly; though even here the hollow, water-worn recesses and caves, which are of frequent occurrence, show how powerful an action the ceaseless beating of the waves exerts upon the hardest materials. And the same thing is the case upon many parts of the iron-bound coast which forms the seaward barrier of a large portion of Britain to the westward.

The estuary of the Humber, including, upon either side, the lowlands of the Yorkshire and Lincolnshire coasts, is undergoing continual and important changes. The water of the Humber is exceedingly turbid, holding in suspension large quantities of earthy sediment (or "warp," as it is locally termed,) which it deposits upon the flats on either side. The alluvial deposits thus formed extend several miles inland, and their level does not exceed that of the average rise of the tide. In some places, however, a continual waste of land is in progress, and serves as a compensation for the gain of solid ground along other portions of the estuary. While large tracts that were formerly occupied by the water have been reclaimed within a recent period, in other places the channel has become considerably widened.

Upon the coast of Norfolk and Suffolk, many villages, and

means of defence were exhausted, the Dutch broke down the neighbouring dykes, and thereby compelled the breaking up of the besieging army, while a fleet of boats advanced across the inundated land to the walls of the city, and carried relief to its gallant defenders, then reduced to the actual verge of starvation.

even towns, have been gradually destroyed by the successive fall of large portions of cliffs, owing to the undermining action of the waves. The town of Cromer, upon the Norfolk coast, no longer occupies its former site, the inhabitants having been compelled to retire inland, as portions of the land have successively given way to the ravages of the sea. The entire site of the older Cromer now forms part of the bed of the German Ocean. The action of the sea is here aided by the agency of land-springs, by which large portions of the upper cliffs are frequently undermined. On the same coast, several well-known villages of former days have disappeared; manors and large portions of neighbouring parishes have been swallowed up, piece by piece; nor has there been any interruption, from time immemorial, in the ravages of the sea, along a tract of coast of twenty miles in length, in which these places stood. Elsewhere, however, nature herself erects a barrier to these and similar ravages. Between Eccles and Winterton, (on the same coast, to the south-eastward,) hills of blown sand, or *dunes*, have barred up and excluded the tide from the mouths of several small estuaries, and similar hills of sand protect the coast between Happisburgh and Yarmouth.

Other instances of like nature might be quoted, as well in reference to other parts of the world as in the case of our own shores, but these examples are sufficient. The sum total of such changes, considered even in reference to a single generation, is by no means inconsiderable, and when viewed in regard to periods of centuries in duration, they become yet more important.

Rivers exert a highly destructive agency in the case of those violent floods, or débâcles, of which their valleys are the occasional seat. Such phenomena are due to the extraordinary force of running water, accumulated in the upper portion of the valley, and afterwards suddenly impelled to burst the confining barrier, pouring a resistless flood through the lower portions of its basin. "The power," says Lyell, "which running water may exert, in the lapse of ages, in widening and deepening a valley, does not so much depend on the volume and velocity of the stream usually flowing in it, as on the number and magnitude of the obstructions which have, at different periods, opposed its passage. If a torrent, however small, be effectually dammed up, the size of the valley above the barrier, and its declivity below, and not the dimensions of

the torrent, will determine the violence of the débâcle." Such barriers are sometimes temporarily formed, in the case of rivers which have their origin in high mountain-regions, by winter ice, the melting of which, with the returning spring, is productive of the most disastrous consequences.

The violent flood which occurred, in the year 1818, in the valley of Bagnes, one of the small lateral branches of the Rhone valley, above the Lake of Geneva, has often been referred to. In this case, the upper portion of the torrent which flows through the valley had been converted into a lake, through the damming up of a narrow pass by avalanches of ice and snow, precipitated from an elevated glacier above. This ice-barrier remained entire until the melting of the snow in the spring, when, after half of its contents had been drained off by artificial means, the increasing heat of the weather occasioned the violent destruction of the entire barrier, and the whole remaining contents of the reservoir were at once poured into the valley below. Rocks, forests, houses, bridges, were swept along by the irresistible force of the flood, and, through the greater part of its course, the stream is described as resembling a moving mass of rock and mud, rather than water. The flood left behind, in the plain of Martigny, thousands of trees, torn up by the roots, together with ruins of numerous buildings. For months subsequently, the bed of the torrent continually shifted from one side of the valley to the other, without any fixed channel.

But an instance of like kind, upon a scale of vastly greater magnitude, occurred in the valley of the river Indus, in the year 1841. The Indus has its origin amidst the glaciers that belong to the Himalaya mountain-region, but the middle and lower portions of its course are through a vast plain. During December 1840, and January 1841, the river, between Torbela and Attock, was observed to be unusually low; at length it was even fordable a short distance above Attock. In April and May it rose, and in June a deluge like an ocean came tumbling and roaring down across the Indian plains, rolling out on either side, travelling with terrible velocity, and making its approach known by a sound like heavy thunder, or the discord of a battle. A stupendous glacier had been formed in the valley of Khundan, and the accumulated drainage of a vast area of the mountain-region had gathered above the obstacle. The ice was like a new mountain, suddenly flung as a barrier across the channel. It was a mile in

thickness. Gradually, however, the heat of the earth beneath, and of the sun above, wore hollows in the frozen mass; the entire glacier at length gave way, and the aggregated waters, sufficient to fill a lake of twelve miles in length, half a mile long, and two hundred feet deep, were poured into the valley. Houses and trees, herds and flocks, men and women, were swept away together, and large alluvial tracts were stripped of their soil. Opposite the fort of Attock, eight hundred miles distant from the Khundan valley, the inundation rushed in one towering wave, breaking over the tops of trees, and rolled on, as sublime as irresistible, until it met the tide of the Indian Ocean, after a career of seventeen hundred miles! "The devastating effects of this terrible flood," says Major Cunningham, "were still quite fresh in 1847. At Tertse, one of the widest parts of the valley, they could be traced to a height of more than twenty feet above the stream, where straws and twigs were massed together in lines two or three feet broad, and upwards of half a mile from the channel of the river. But the most striking effect of the flood was the entire absence of trees in the valley of the Shayok, while the lateral valley of Nubra was full of trees upwards of a hundred years old. . . . The shepherds and herdsmen, with their flocks and herds, were overwhelmed in the midst of the open plain, without a chance of escape." . . . "At Torbela," says an eye-witness, "about 2 P.M., a murmuring sound was heard from the north-east among the mountains, which increased until it attracted universal attention, and we began to exclaim, 'What is this murmur? Is it the sound of cannon in the distance? Is Gandgarh bellowing? Is it thunder?' Suddenly some one cried out, 'The river's come!' And I looked, and perceived that all the dry channels were already filled, and that the river was racing down furiously in an absolute wall of mud; for it had not at all the colour or appearance of water. They who saw it in time easily escaped. They who did not, were inevitably lost." . . . Throughout the mountain-course of the river, the devastation caused by this terrible flood in the lowlands along the banks of the stream was complete. All the cultivated lands were swept away, and not even a single tree was left standing to mark the spot where careful tillage and laborious irrigation had for hundreds of years wrung luxuriant crops from the thirsty soil.*

* Ladakh, Physical, Statistical, and Historical. By Major A. Cunningham. London, 1854.

Reference has been made to deltas in a preceding page.* They consist of alluvial soil, the material of which has been brought down by a stream from the higher portions of its course, more particularly during those seasons of flood to which all rivers that derive their waters from mountainous districts are more or less liable. There is a constant tendency for such sedimentary matter to be deposited in the bed of the stream; and this tendency is greatly increased at the embouchure of the river, where its waters meet the sea, especially if there be any local current preserving a direction at right angles to that of the stream itself. Hence the formation, and frequent shifting, of sand and mud banks in the beds of rivers; and hence also the bars which are so often formed at their mouths. It is only where, owing to local conformation of the surface of the ground, the main channel of a river divides into two or more branches, that a delta is formed. In such cases, the continual deposit of alluvial † matter tends to increase the extent of the delta—the newly-formed soil gradually advancing itself further out into the sea. The gain of land thus occasioned is in some cases considerable, though much less in amount than (at least in the existence of some well-known deltas) has frequently been suggested. The rounded shape—convex towards the sea—which many deltas (as those of the Nile, the Po, the Rhone, the Ganges, and other streams) exhibit in their contour, results from the continual growth of land within the space that is enclosed between the outer arms or channels.

The mouths of the Po and Adige furnish one of the most striking examples of growth of land due to the agencies here referred to. The waters of both these streams are abundantly charged with the sediment which their numerous feeders, swollen with every succeeding spring by the melting of the winter snows, bring down from the Alps and Apennines. The continual deposit of this matter towards the lower portion of its channel has, in the course of ages, raised the *bed* of the Po above the level of the adjacent plains, so that it requires to be confined between artificial embankments upon either side; and the same cause has tended to a continual growth

* Page 59.

† Latin, *alluo*, I wash upon. "The term *alluvium*" (of which alluvial is the adjective form) "comprehends," says Lyell, "earth, sand, gravel, stones, and other transported matter which has been washed away and thrown down by rivers, floods, or other causes, upon land not *permanently* submerged beneath the waters of lakes or seas."

of alluvial soil along the Adriatic coast, where the river meets the sea. Within the last two thousand years, this growth of land has amounted in some places to a breadth of twenty miles, and throughout a line of coast measuring a hundred miles in length, the growth of land varies from two to twenty miles. The town of Adria, which was a seaport in the time of the Romans, is now nearly twenty miles inland. The delta of the Rhone presents a like example of growth, though less rapid.

Both the Ganges and the Indus exhibit instances of considerable and constant growth of land at their outlets, as well as of frequent changes in their channels. So great is the quantity of mud and sand annually poured by the Ganges into the Bay of Bengal in the season of flood, that the sea only recovers its transparency at the distance of sixty miles from the coast. The main channel by which the waters of the Brahmapootra river (the arms of which unite with those of the Ganges at their outlet, and form with it a joint delta of many thousand square miles in area) reach the sea has altogether shifted its place within a recent period. The delta of the Mississippi furnishes a like example in the New World. The tongue of land now projects far out, beyond the general line of coast, into the waters of the Mexican Gulf, and has advanced many leagues since the city of New Orleans was built.

IGNEOUS CAUSES OF CHANGE.—The phenomena due to the agency of the earth's internal heat make themselves manifest, at least for the most part, by sudden and violent action, frequently attended by catastrophes of the most disastrous description. The earthquake and the volcanic eruption have been, in all ages, among the most fruitful causes of disaster incident to the works of nature, and have been repeatedly attended by loss of life, and other suffering to the human race, to an amount which it is frightful to contemplate.

The earthquake and the volcanic eruption may, with the highest probability, be regarded as allied phenomena, and as exhibiting the action of the earth's internal heat upon the outer surface of the globe. The proximate cause of earthquakes is probably to be found in the chemical changes which result from the mutual action of various substances

composing the crust of the earth, and which changes are connected with development of heat through the hidden agency of electricity. But the intense force manifested in such phenomena, not less than certain conditions which accompany their recurrence in particular districts, points to some more deeply-seated and general cause; and there can hardly be a doubt that this is found in the heated condition of the earth's interior. That subterranean heat exists in every part of the earth—warm and cold regions alike—is a well-known fact: experiments made in widely-distant localities show a nearly uniform rise of temperature from the surface of the ground downwards, the ratio of increase being in the proportion of one degree of Fahrenheit's thermometer for about every sixty feet of perpendicular descent.*

It is true that the greatest depths to which the operations of man have penetrated affect no more than a thin pellicle of the earth's crust, the deepest mines scarcely exceeding two thousand feet. But the rise of temperature here adverted to would not be found of such wide and uniform distribution were it not due to some general cause. The wide-spread occurrence of hot springs, again, is evidence of the heating agencies which exist at considerable depths below the earth's surface. The manifestation of these heating agencies is probably connected with local conditions of natural formation which are beyond the reach of man's direct observation, as well as with chemical and electrical forces. The elastic gases contained in cavernous reservoirs beneath the ground tend, under the influence of heat, to burst the covering within which they are confined, and produce, by the force which they exert, an upheaval or disrupture of the solid crust of the globe—that is, an earthquake.

It appears, from the accurate records of such phenomena which have been kept within recent periods, that earthquakes are of much more frequent occurrence than is commonly supposed. Upwards of three thousand earthquakes are recorded as having occurred within the first half of the present century

* The heat which exists below the superficial covering of the globe is nowhere more strikingly manifested than in the case of such regions as Siberia, or the Arctic latitudes of North America, where, owing to intense severity of climate, the subsoil remains permanently frozen at the depth of a few feet—the heat of the short Arctic summer only thawing the ground to a trifling distance below the surface. But this frozen subsoil is itself only a stratum of limited thickness, on penetrating below which the temperature again rises, the increase of heat, here as elsewhere, bearing a direct ratio to the depth.

—an average of more than one for every week throughout the entire period. But not more than one in forty is of considerable importance, by far the greater number consisting of such slight shocks as are occasionally experienced in Britain and other countries favoured with a like immunity in this regard. An important earthquake, however, in some part of the world or other, appears, from the above average, to occur once in every eight months.

In Europe alone, where a more complete record of such occurrences is obtainable than in other parts of the world, as many as 320 distinct earthquakes are recorded to have occurred within a period of ten years (1833–1842)—an average of thirty-two annually, and of one such shock for every ten days throughout the period.*

The area within which shocks of earthquake are experienced is a widely-spread one, and does not appear to undergo any material change (if, indeed, any change whatever) as to its limits. At any rate, the regions in which violent earthquakes are recorded to have occurred in former times are those in which such disturbances are of most frequent recurrence at the present day. One of the most striking evidences in favour of the supposition that the volcanic eruption is due to the same deeply-seated cause which produces the shock of the earthquake is afforded by the fact, that all the volcanoes which have been in eruption within the modern period of geology are found within regions liable to earthquakes, and, for the most part, to violent shocks.

Regarding the earthquake and the volcanic eruption as the manifestation, under different conditions, of the earth's internal fires, we readily mark out upon the globe the great regions of geographical distribution in the case of such phenomena. The most widely-extended of these coincides with the circuit of the Pacific Ocean. Along the entire western coast of the New World, from Tierra del Fuego to the peninsula of Alaska and the neighbourhood of the Aleutian Islands, shocks of earthquakes are known to occur; and, within a large portion of the space, vents of active eruption are found. The subterranean igneous force is, indeed, much more powerfully displayed in the southern than in the northern half of the American continent, and the active volcanoes that occur within the limits referred to are nearly all found amidst the

* Professor Ansted: Lectures before Royal Institution, 1860.

cordilleras of the Andes, or upon the plateaus of the Mexican isthmus. Chili, Peru, and the western portions of Columbia —in fact, the whole range of country lying along the west coast of South America—have frequently experienced shocks of earthquake of the most violent description, many of them so considerable as to occasion great and permanent changes in the level of the ground, and a few days (or at most a week or two) rarely pass away without some minor indications of the force which is at work beneath. In the Patagonian Andes, the most southward portion of the great mountain-system, four active volcanoes occur between the parallels of 44° and 42° S.; and of the Chilian Andes, no fewer than nineteen are active volcanoes. The Andes of Bolivia and Peru contain fewer points of eruption, and between the parallels of 30° and 23° no active volcanoes occur; amongst the double chain of the Columbian Andes, in the immediate neighbourhood of the equator, numerous volcanoes are again found. Amongst them, within the province of Quito, and nearly under the line of the equator, is Cotopaxi, upwards of 18,000 feet in altitude, and the highest of the volcanoes that has been in a powerfully active condition within the modern period. Upon the western side of Central America, again, active volcanoes line the shores of the Pacific; further to the northward, several insulated volcanic peaks rise above the Mexican table-land. One of the Mexican volcanoes—Jorullo—is especially deserving of notice, from the circumstance of its having first risen above the surrounding plain by the accumulation of volcanic matter during an eruption in the year 1759.

The Aleutian Islands connect the volcanic region of the eastern Pacific with that which extends along its western shores. In the latter case, however, it is upon the peninsular regions, or in the chains of islands that adjoin the mainland, that the igneous force is displayed. Kamschatka, the Kurile Islands, Japan, and the entire region of the East Indian Archipelago, exhibit the presence of igneous force below the ground. Seven active volcanoes occur in Kamschatka; and Japan is said to contain numerous burning mountains. Between Japan and the Loo-choo group is Sulphur Island, an insular volcano, from which smoke is constantly emitted. The islands of the East Indies exhibit displays of volcanic force only paralleled in frequency and intensity by the vol-

canic region of the Andes. In Java alone there are forty-three active volcanoes, ranging in a linear direction from east to west, through the length of the island. Thence the volcanic chain is prolonged, in one direction, to the northwest, through Sumatra, and as far as Barren Island, in the Bay of Bengal; and in another direction, to the eastward and south-eastward, through the Lesser Sunda islands, and the northern shores of New Guinea, towards the western groups of Polynesia. Further to the southward, in the same general direction, it is traced in the northern island of New Zealand, in which slight shocks of earthquake have not been unfrequently experienced, and which contains likewise other evidences of volcanic action.

The Pacific is, then, girdled by a great chain of subterranean fire, nor are there wanting evidences of the volcanic heat being as powerfully active in the midst of the ocean's bed as upon the surface of the adjacent land. The Sandwich Islands contain (in Owhyhee, the largest of the group) one of the most powerfully active of modern volcanoes—the Mountain of Kilaueh.

Another great volcanic region is traced in connexion with the waters of the Atlantic, and those of its great offset, the Mediterranean Sea. The south-western shores of Asia, the southern shores of the European continent, and the north-western portion of the African mainland, are included within the limits of this region, which extends from the neighbourhood of the Caspian Sea, on the one hand, to the volcanic archipelago of the Azores, on the other. There are here fewer active vents of eruption; but frequent shocks of earthquake are experienced through its entire extent. Syria, Asia Minor, Greece, Southern Italy, the Spanish Peninsula, and the region of Mount Atlas, in North-western Africa, are all liable to the frequent repetition of such convulsions. The only portion of the Mediterranean coasts exempt from such disturbing phenomena is on its southern shores, embracing that part of the North-African coast which stretches between the Lesser Syrtis and the Isthmus of Suez, including the valley of the Nile. We have no record of the experience of any shocks of earthquake in Egypt. Had it been otherwise, perhaps the pyramids of that land of wonders might have proved less enduring monuments of the past.

Besides the widely-extended areas above adverted to, there occur, in either hemisphere, regions of volcanic activity, in

which—though over a smaller geographical extent—the subterranean heat of our planet displays itself on a scale of equal intensity. Iceland, in immediate proximity to the Arctic circle, is one of these; and Jan Mayen Island, five degrees nearer to the northern pole, may be regarded as an outlying member of the Icelandic volcanic region. On the southern side of the globe, the Island of Bourbon, in the Indian Ocean, displays the presence of active volcanic force in the frequent fires of one of its pitons. In a much higher latitude, within a distance of only twelve degrees from the southern pole, in the tract of land upon which Sir James Ross, who was its discoverer, bestowed the name of South Victoria, there is found the active volcano of Mount Erebus, rising to an altitude of more than twelve thousand feet—a sublime object in itself, and rendered the more striking by the contrast which the aspect of its glowing summit presents to the ice and snows gathered within the polar circle.

The interior of the Asiatic continent presents us with a region of volcanic disturbance further removed from either of the great oceanic basins than is elsewhere found. Two, if not more, among the summits of the Thian-shan chain, which stretches through Central Asia, are active volcanoes, and shocks of earthquakes are experienced in the adjacent tract of country. Over the greater part of the Indian peninsula, particularly on the northern side of the valley of the Ganges, and in the tract adjacent to the Lower Indus, earthquakes are experienced, as well as in the region which stretches between the western portion of the Himalaya and the valley of the Oxus. In the western part of the Arabian peninsula, and upon the Abyssinian plateau, upon either side of the Red Sea, similar phenomena are experienced. The lower portion of the Mississippi valley, and some parts of the country bordering on the river and gulf of St Lawrence, are also subject to the occasional occurrence of such shocks, though with a modified degree of intensity.

The movement imparted to the ground during an earthquake may be either horizontal or vertical. In the former case, the phenomenon consists in an undulating, wave-like movement; in the latter, in an upheaval or subsidence of land. The vertical shock affects most the relative levels of adjacent objects, and produces the most striking permanent changes in the natural aspect of the region in which it is

experienced. But the undulatory movement is attended by more serious consequences to man, since it at once shakes the foundations of the strongest edifices, and may overthrow in the space of a few seconds the accumulated labours of prior ages. Whole tracts of land, with their cities or villages, may be elevated or depressed with comparatively little injury to life; but nothing can withstand the force of a motion which rocks the solid strata of the earth itself. The most solidly-constructed buildings are not proof against the earthquake, any more than the weakest. Indeed, it has in many instances been observed that those erections which displayed the strongest masonry have suffered more from the effects of an earthquake than buildings of slighter structure. The cracking of walls, the falling-in of roofs, and the crash of tumbling houses on every side, burying their inmates beneath the ruins, are among the characteristics of the earthquake in its most violent and frightful form.

A third kind of movement is sometimes, though more rarely, exhibited during the earthquake,—that, namely, which assumes a vorticose or rotary direction. This is sufficiently proved by results observed in various instances. Portions of buildings have been partially twisted round during a violent shock, and isolated columns or statues have been found, after such an occurrence, to face a different quarter from that which they previously did. During the Chilian earthquake of 1835, vessels moored alongside of one another in the harbour of Concepcion, were afterwards found with their cables twisted together. Some of the vessels were thrown violently against others, and whirled about as if they had been in the vortex of a whirlpool.

The duration of any single earthquake shock is seldom more than a few seconds, though the terror which it inspires naturally tends to make it seem of longer continuance; but in the case of the more violent movements, even a few moments serve to destroy the work of ages. In the Chilian earthquake of 1835, the great shock which destroyed the city of Concepcion was preceded by several tremulous movements of minor intensity. During the first half minute, many persons remained in their houses; but the convulsive motion of the earth then became so strong that all rushed into the open streets for safety. The horrid motion (writes an eye-witness of the scene) increased; people could hardly stand; buildings waved and tottered; suddenly an awful and over-

powering shock caused universal destruction. In less than six seconds the city was in ruins ! *

The earthquake is propagated to enormous distances from the region in which the shock originates, the rate at which the motion travels varying, not merely with the violence of the originating impulse, but also with the nature of the formations through which it passes. Rocks of solid and homogeneous texture, as granite, favour the transmission of the shock; while formations of loose texture, such as sand, most retard its speed.† The well-known Lisbon earthquake of 1755, by which sixty thousand persons are said to have perished within the brief space of six minutes, was felt in the British Islands, as well as upon the coast of Barbary, and even among the islands of the West Indies, on the opposite side of the Atlantic. ‡

The southern portion of Italy constitutes one of the regions in which earthquakes have occurred with the greatest frequency in modern times, and in which the disastrous conseqences that often attend on such catastrophes have been experienced in the fullest extent. Within scarcely more than the last three quarters of a century, as many as *six* great earthquakes, not reckoning minor shocks, have laid waste extensive tracts of that beautiful and in other regards highly-favoured region, causing great loss of human life, as well as in various ways the most frightful suffering and distress. The *first* of these was the often-described Calabrian earthquake of 1783–6, which commenced on February 5 with a violent shock, which in less than two minutes levelled to the ground more than a hundred towns and villages, and buried 32,000 of their inhabitants under the ruins. Other shocks succeeded, and by the beginning of 1784, Calabria had already lost more than 80,000 of its inhabitants. Between the months of February and December 1783, there were not fewer than 949 shocks; 151 shocks occurred during the succeeding year, nor did they altogether cease until 1786. The changes consequent upon this lengthened period of disaster were of the most striking description. Mountains were cleft asunder,

* Journal of Royal Geographical Society, vol. vi.

† Mallet.

‡ The shock travelled to Corunna at the rate of 1994 feet per second; to Cork, at the rate of 5280 feet; and to Santa Cruz, in Barbary, at the rate of 3261 feet.

high cliffs tumbled down, rivers turned from their beds or dammed up in their courses, lakes formed, valleys elevated into hills, deep chasms opened, the physical aspect of the country changed, the landmarks of property removed, and the relations of society in great measure disorganised.

The *second* of the catastrophes above referred to, in connexion with this devoted region, occurred in 1804, when the province of Molise was the centre of a violent earthquake, which lasted 35 seconds, and caused great desolation over an area of six hundred square miles, involving the destruction of 61 towns and villages, with a loss of 6000 lives. The *third* took place in 1835, when the town of Cosenza, and a large adjoining tract of country in the province of Calabria Citra, suffered severely. The neighbouring province of Basilicata was in 1836 the scene of a violent convulsion, and again experienced, fifteen years later (1851,) a succession of destructive shocks, of which the town of Melfi was the focus. *Last* in order of enumeration comes the earthquake of 1857–8, of greater violence, and more destructive in its results, than any experienced within the same region since 1783. The first shock was experienced on December 16, 1857, and during the two succeeding months a slight shock was felt almost periodically just before sunrise; nor did they altogether cease for some considerable subsequent period. The seat of this convulsion was in the central group of mountains in the provinces of Basilicata and Principata Citra, a part of the southward prolongation of the Apennine chain. Within an area of about 216 square miles, over which the more violent action extended, more than 12,000 persons (above a third of the resident population) were in less than half a minute crushed to death, and two thousand severely wounded. The ground was cracked and convulsed in the strangest manner; chasms and deep fissures were opened in several places, fertile hills became bare rocks, valleys were raised up, small pools formed, and mountains cleft by deep ravines. The destructive effects of the earthquake extended, with slightly diminished intensity, over a much wider area, embracing upwards of three thousand square miles, and even reached, in a mitigated form, over the whole mainland of Southern Italy, from the extremity of Calabria as far northward as the towns of Terracina, on the border of the Papal States, and Vasto (lat. 42° 8′), on the coast of the Adriatic —a distance of three hundred miles in direct lineal measure.

A vast number of towns, within these wide limits, sustained more or less injury. On the whole, at least 22,000 human beings, on the most moderate calculation, were destroyed within a few seconds by this terrific earthquake.*

VOLCANIC ERUPTIONS.—The most obvious characteristic of a volcanic mountain, when not actually burning, whether its fires be extinct or merely dormant, is its shape. The volcano is always of a form more or less conical, with the apex or point of the cone truncated, and, in its place, a hollow or depression towards the heart of the mountain—the well-known *crater*.† Besides the principal crater there are, in the case of some volcanoes, numerous minor cones of eruption, from which the central fire has made its force manifest at different periods. Thus no fewer than eighty minor cones, each with its separate crater, are irregularly scattered around the sides of Etna.

When its fires have been dormant for any lengthened period, the volcano may exhibit, in the aspect of its crater, nothing calculated to disturb the idea of profound calm and repose. In the early part of the seventeenth century, when there had been no violent eruption of Vesuvius for a period of nearly five centuries, the appearance of the mountain is thus described:—"The crater was five miles in circumference, and about a thousand paces deep; its sides were covered with brushwood, and at the bottom there was a plain upon which cattle grazed. In the woody parts wild boars frequently harboured. In one part of the plain, covered with ashes, were three small pools; one filled with hot and bitter water, another salter than the sea, and a third hot but tasteless."‡ But in 1631, this state of repose was violently interrupted; the grassy plain and wooded sides of the crater were blown into the air, and the volcano again exhibited itself as a duct of connexion between the heated interior of our globe and its external superficies.

The general direction of the strata of which the mountain is composed, dipping from the centre *outwards*—a natural consequence of the accumulated showers of ashes and other ejected matter—is another indication of volcanic agency in

* Dr J. P. Lacaita "On the late Earthquakes in Southern Italy"—paper read before the Royal Institution of Great Britain, 1858.

† Latin—*crater*, a cup.

‡ Hamilton's "Campi Phlegræi," quoted in Lyell, vol. ii. p. 77.

its formation. But besides these marks, and more unvarying than either, is the information conveyed to the geologist by the structure of the rock, which, in the case of a volcano, (whether of ancient or modern date,) always possesses a vitreous aspect and fracture, exhibiting a tendency towards crystalline arrangement of its particles. This alone would determine the volcanic character of the mountain, even though all traces of a crater were lost, and the form was entirely different from what it ordinarily is. Where streams of lava have flowed from the crater, their position relatively to other beds of rocks, aided by an examination of the fossils which the latter contain, determines the respective ages of their issue. Thus the lavas of Ischia (a small island on the northern side of the Bay of Naples) must have flowed since the period when the waters of the Mediterranean first became peopled with their present forms of life; because in the beds of rock interstratified among them, there are found numerous species of *testaceæ* identical with those now existing in the adjacent sea. Yet no signs of volcanic activity have been experienced in Ischia for the last five centuries; and previous to the year 1302 (when a violent eruption occurred) it is believed to have been at rest for a lengthened period. Its fires are dormant, but they belong to the modern period; and the island must be included within the volcanic region lying around Naples, and claiming Vesuvius as its prominent feature.

Extinct volcanoes must be distinguished from those that are in an active condition, or of which the fires are merely slumbering. In the case of the former, the geological evidence proves that neither lava nor any other matter has issued from them during the whole of the modern period, or that within which the earth has been inhabited by its present forms of life, vegetable or animal. Yet they may present a perfect analogy to the seats of modern volcanic fire, in so far as external appearance is concerned. There are many hundreds of such mountains in the district of Auvergne, in central France, each with its proper crater, a perfect volcano in form, and with abundant evidence of activity at a long-distant epoch. But this and similar regions of ancient volcanic force have no connexion with the areas of *present* subterranean fire.

Nearly three hundred active volcanoes are known, above two-thirds of the number being found in close proximity to

the Pacific Ocean. In no other region of corresponding extent are there so many as in the island of Java. The list is of course subject to increase by any first display of volcanic force in the case of mountains which have hitherto given no outward indication of their contained fires. In the case of some volcanoes, the potency of the subterranean fire seems to be gradually diminishing, and its effects are limited to the issue of sulphureous and other gases, continually emitted from the crater. A volcanic mountain in this condition is called a *solfatara*,—a name derived from that of a nearly-extinguished crater near Puzzuoli, on the shore of the Bay of Naples.* Teneriffe and others of the Canary Islands, with Stromboli, in the Lipari group, and some of the volcanic islands in the Greek archipelago, are in the condition of solfataras.

The following list includes a few of the principal active volcanoes in either hemisphere, with their elevations :—

WESTERN HEMISPHERE.		EASTERN HEMISPHERE.	
Arequipa (Andes)	12,820	Kliuchevsk (Kamschatka)	16,512
Antisana (do.)	19,137	Slamat (Java)	12,300
Cotopaxi (do.)	18,877	Indrapura (Sumatra)	12,300
Tolima (do.)	18,026	Tomboro (Sumbawa Island)	7,600
Popocalepetl (Mexico)	17,773	Teneriffe (Canary Islands)	12,236
Orizava (do.)	17,373	Fusi (Niphon: Japan)	12,000
Tunguragua (Andes)	16,579	Etna (Sicily)	10,874
Toluca (do.)	15,271	Piton de la Fournaise (Re-union)	7,200
Erebus (S. Victoria)	12,400	Beerenberg (Jan Mayen Island)	6,870
Kilaueh (Sandwich Islands)	3,970	Hekla (Iceland)	5,095
Cosiguina (Central America)	1,000	Vesuvius (Italy)	3,932

The gases given out by volcanoes are muriatic acid, sulphur combined with oxygen or hydrogen, carbonic acid, and nitrogen; together with immense quantities of aqueous vapour.† There is, besides, a variety of ejected matter, among which are comprised ashes, (often in dense showers,) with stones, masses of rock, and various substances comprehended under the term "scoriæ," and, in many cases, streams of lava. The aqueous and gaseous vapours produce that appearance of smoke which generally heralds an eruption, and the semblance of flame by which it is accompanied proceeds, in most cases, from the clouds of red-hot ashes, aided by reflec-

* An instance (like the case of the word "delta") of the extension of a geographical term from a special to a general sense. The solfatara near Puzzuoli appears to have been in nearly the same state before the Christian era as at the present time, giving vent only to aqueous vapours, with sulphureous and other gases.

† Daubeney: "Description of Active and Extinct Volcanoes."

tion (from the dense masses of vapour) of the glowing light emitted by the lava in the interior of the crater, which is literally a sea of liquid fire. In some instances, however, the seeming flames may be produced by inflammable gases in a state of actual ignition.

The amazing force with which the ejected matter issues from a volcano, and the vast distances to which it is thrown, show how powerful is the cause to which volcanic phenomena are due, and point to some deep-seated origin, of a nature analogous to the forces operating in the general structure and movements of the natural world. The ashes ejected from Tomboro (in the island of Sumbawa, one of the Lesser Sunda chain,) in the eruption of 1815, were carried on the side of Java to a distance of three hundred miles, and upwards of two hundred towards Celebes, in the opposite direction, in sufficient quantity to darken the air. The sound of the accompanying explosions was heard in Sumatra, at a direct distance of 970 geographical miles, and the cinders floating in the sea to the westward of that island formed a mass of two feet in thickness, and of many miles in extent.*

A parallel instance may be quoted from the records of volcanic phenomena on the opposite side of the globe, in the case of the eruption of Cosiguina, (N. lat. 13°, W. long. 87° 30′,) one of the volcanoes of Central America, at the southern entrance of the Gulf of Conchagua, an arm of the Pacific. This eruption occurred on the 20th January 1835, and was preceded by a loud noise, as from salvos of innumerable artillery, apparently proceeding from various parts of the gulf, while an enormous coal-black cloud rolled up high above the summit of the mountain, which was entirely hidden by it. At San Salvador (upwards of 110 miles distant in a straight line) total darkness overspread the whole sky, and the air was filled with a fine ash, productive of the most suffocating effects. At intervals was heard a tremendous roar of subterranean artillery, as if a thousand cannons were fired together, and the noise from the gulf side was like that of a naval engagement, in which all the navies of the world were contending—the detonations being heard for several hundred miles. In

* This eruption was one of the most frightful on record. Out of a population of 12,000, only 26 individuals survived on the island. Great tracts of land were covered by the lava which issued from the mountain. Violent whirlwinds occurred simultaneously, and created much damage. The particulars are given in Sir Stamford Raffles' "History of Java," quoted by Lyell.

the direction of the gulf there were afterwards found the dead bodies of thousands of animals, especially birds, who had probably been beaten down by the scoriæ, or suffocated by the ashy dust; and amongst the pieces of light pumice stone which covered the waters of the gulf were seen the bodies of countless inhabitants of the sea, of all sizes, from the smallest molluscs and crustaceæ to the huge carcases of sharks and crocodiles, who appear to have been killed by the high temperature communicated to the sea by the glowing masses of scoriæ that fell into it. Dead fish were found in great numbers on the surface of Lake Managua, ninety miles off, and the water was entirely covered with ashes.

"The distances," (says Dr Scherzer,) "at which the thunder of this eruption was heard would appear quite incredible were not the fact confirmed by so many still living witnesses. In the capital of Guatemala, 240 miles in a straight line from Cosiguina, the concussion of the air was such as to make the windows shake at every detonation; and in the British colony of Belize, 300 miles off, the supposed artillery was loud enough to induce the English governor to order out the garrison. He imagined that there was a sea-fight going on in the neighbourhood, as the atmosphere was too clear for him to attribute the sound to thunder. In the opposite direction, the circle of detonation is stated to have extended southward to New Granada and Quito, close to the equator, and part of the ejected matter was still more widely diffused. Not only in all parts of Central America, but even in the highlands of Mexico, in Vera Cruz, Cuba, and Jamaica, ashes were seen to fall from the sky, and the astonished people could not for a long time discover the cause of the puzzling phenomenon." *

Lava is unquestionably the most important of volcanic products, but its occurrence during an eruption is by no means uniform. No lava issues from the volcanoes of the Andes, though streams of it have flowed from some of the volcanic cones that rise above the Mexican plateau. Immense quantities of lava have repeatedly issued from the Icelandic volcanoes. Even in the case of Vesuvius, and other lava-emitting volcanoes, the ejection of lava is not a uniform accompaniment of the eruption. No lava issued from Vesuvius during the tremendous eruption, the first on record, of A.D. 79, when Pompeii and Herculaneum were destroyed. These

* "Travels in the Free States of Central America," &c. By Dr Carl Scherzer. London, 1857.

cities were buried beneath the shower of ashes ejected from the crater of the mountain. The excavations of modern times have restored Pompeii to the light of day, after the lapse of seventeen centuries.

When first issuing from the mountain, the lava flows in a smooth but rapid torrent, in regular channels, and in a perfect state of fusion. But as it advances, and its stream widens, it speedily loses this smoothness of aspect, becoming a dense, viscous, and semi-fluid substance, easily deflected from its course by irregularities in the surface of the ground, and travelling onwards with a slow and steady motion. Bodies of even considerable weight, as stones weighing ten or fifteen pounds, make little or no impression on the surface of the stream, but larger masses of rock become slowly and gradually absorbed in it. The front and sides of the lava-torrent present well-defined lines; their immediate contact with the atmosphere causes them to cool sooner than the central parts of the stream, and to consolidate earlier, while the more liquid portions flow over their hardening mass,—particular parts thus becoming heaped up in rocky waves. The entire body of the lava contracts as it parts slowly with its heat, and opens in numerous cracks and fissures, so that the tract over which a lava-stream has flowed exhibits subsequently a broken, rugged, and blackened aspect, irregular masses of the lava rock being mixed with heaps of cinders and other volcanic substances. But atmospheric influences gradually soften the more prominent features of the scene, and the disintegrated lava-torrent often becomes, in process of time, converted into a soil of more than ordinary fertility.

The mineral composition of lavas is various, and, according as different elements prevail in their composition, they are termed trachytic, basaltic, or by other designations. The substance called felspar predominates in most modern lavas: that called augite is most abundant. Hornblende is rare in modern lavas, though abundant in igneous rocks of more ancient origin. Quartz is also rarely exhibited in a separate form in recent lavas, though it forms so important an ingredient in granite and other rocks of igneous origin. The term *trap* is used by geologists to embrace all volcanic rocks of ancient origin, and is derived from the Swedish word for a step (*trappa*), from the fact that rocks of such a kind are often found in successive platforms, one above another. Trap rocks differ from lava in the fact of their having originated

beneath the pressure of water, and their being intermixed with sedimentary deposits, while lava has issued directly from the mountain, and cooled under the influence of the atmosphere ; the mineral character of each is, however, essentially the same. Torrents of water and mud often sweep down the mountain side during an eruption, and not unfrequently cause as much devastation as the more characteristic products of volcanic action. They are, no doubt, frequently (probably in the great majority of instances) derived from the sudden condensation of aqueous vapour, as it rises into the higher and colder regions of the air. Sometimes the sudden melting of snow that has gathered round the mountain's summit, during its intervals of repose, produces a similar result. Frequent instances of the latter kind have been known to occur among the volcanoes of the Andes, many of which, Cotopaxi amongst the number, rise high above the snow-line, and are, for the most part, conspicuous by their icy and glittering covering. But in some instances there is no doubt that water is amongst the ejected products of the volcano, and with it thousands of fish, that have lived within the subterranean reservoirs of the mountain. Amongst the volcanoes of Central America, there is one called the Volcan d'Agua, or water volcano, from which streams of water are alone ejected.

Submarine eruptions are of not unfrequent occurrence, and their effects are by no means limited to merely temporary disturbances of the waters of the ocean. Many instances might be quoted of permanent elevation of the bed of the sea, and the formation of hidden rocks, perilous to the navigator, where there had been deep water previous to the eruption. Islands—in some instances permanent, in others only temporary—have thus been elevated from the bed of the sea by volcanic agency. One of the most striking examples of such a kind occurred in 1831, in the case of Graham Island, (as it has been most generally called,) which was thrown up from the bed of the Mediterranean Sea, at a distance of about thirty miles to the southward of Sicily. At the end of June, in that year, slight shocks as of an earthquake were felt by a vessel passing over the spot indicated, followed (about a fortnight later) by a column of water rising to sixty feet above the sea, with dense clouds of vapour. This was shortly succeeded by the appearance of a small island twelve

feet high, with a crater in its centre whence volcanic matter and vapour were continually ejected, while the sea around was covered with floating cinders. The eruption continued for some weeks with great violence, the size of the island continually increasing by the accumulation of newly-ejected matter, until it attained its maximum dimensions of three miles in circumference and more than two hundred feet in height. It afterwards gradually diminished, the loose volcanic matter being washed away by the waves. By the end of October, the island was nearly levelled with the surface of the sea, and afterwards wholly disappeared, leaving, however, where there had formerly been a depth of more than a hundred fathoms, a dangerous reef, composed of solid rock, most probably lava.

Several similar cases are on record in other localities, as in the neighbourhood of the Azores, off the coast of Iceland, and among the Aleutian Islands. A peculiar agitation of the waters of the ocean, as by some powerful force beneath, and quite distinct from the kind of movement due to atmospheric influences, is indeed by no means uncommon in the experience of mariners, and is often followed by the issue of smoke and gaseous matter above the surface of the water. A particular part of the Atlantic Ocean, in the neighbourhood of the equator, has been noticed as a locality in which such phenomena are of more than ordinary frequency.

Mud-volcanoes—that is, small volcanic cones from which take place periodical ejectments of gases and water, mixed with mud—are amongst the many forms in which eruptive force is manifested. Their action has been frequently referred to some secondary cause, (as the burning of inflammable strata below,) rather than to any deeper-seated agency, but it is more probably correct to regard them as real volcanic phenomena, and to connect them with the widely distributed subterranean heat of the globe, and the fact of their occurrence only within volcanic regions lends strong confirmation to this view. Mud-volcanoes occur in the island of Sicily (near the town of Girgenti), in Java, and in the neighbourhood of the Caspian Sea. The *volcanitos*, or air-volcanoes, of New Granada, South America, described by Humboldt, may be classed with such phenomena. They occur in the neighbourhood of Turbaco (a few miles distant from Carthagena), about two miles to the eastward of that village, in the midst of a thick forest, which

abounds in balsam-of-tolu trees, as well as in other rich productions of the tropical flora. The land gradually rises, as they are approached, to the height of 120 or 150 feet above the village of Turbaco, and in the middle of an extensive plain eighteen or twenty small cones are observed, each with an elevation of from twenty to twenty-five feet. These cones are formed of a blackish-grey clay, and an opening filled with water is found at the top of each. On approaching these little craters, there is heard, at intervals, a hollow but distinct noise, which precedes by from fifteen to eighteen seconds the disengagement of a large body of air. Humboldt counted five explosions within two minutes. The phenomenon is frequently accompanied by an ejection of mud.

The *geysers* of Iceland are to be regarded as evidence of the various ways in which the earth's internal heat manifests itself upon the superficial covering of the globe. The geysers are intermittent hot springs.* At irregular intervals, rarely exceeding twenty-four hours, the geysers throw up columns of boiling water and steam. In the case of the great geyser (as the principal fountain is called) the water is ejected to the height of from eighty to a hundred feet, accompanied by subterranean noises and loud explosions, while sometimes the earth is slightly shaken during the occurrence of the phenomenon. If stones are thrown into the crater or circular mound out of which the fountain rises, they are instantly ejected with amazing force. The geysers rarely play for more than a few minutes at a time. In the intervals between its eruptions the basin of the principal fountain is sometimes empty, but is more frequently filled with water in a state of ebullition. In the case of the geysers, there is no doubt that steam is the immediate cause of the phenomena which are exhibited. They occur amongst a thick bed of lava in the south-western part of the island, and at a distance of about thirty miles from Mount Hecla. In this district, the rushing of water beneath the ground is frequently heard, and the streams, as in similar cases elsewhere, flow in subterranean channels through the cavernous lava.

Gradual rise or subsidence of land.—To the more obvious and violent forms of volcanic action above described, there requires to be added one, in which the same agency operates

* The word *geysa*, Icelandic, signifies to rage, or burst forth impetuously.

much more slowly, and to outward appearance imperceptibly, in the production of a like result. The gradual rise or subsidence of large tracts of land is a well-ascertained phenomenon. A large part of Sweden furnishes an instance of this. Careful observation has shown that throughout the greater part of the Scandinavian peninsula, from the North Cape southward to the neighbourhood of Stockholm, there is a gradual rise of land, at a rate varying in amount from several feet to only a few inches in a century. It is greatest in the extreme north of the peninsula, and thence diminishes to the southward. The extreme south of Sweden undergoes a movement in the opposite direction—*i.e.*, a gradual sinking or depression. The seat of this continual, though slow, alteration of level between adjoining land and sea is far removed from the ordinary manifestation of volcanic agency. There are no volcanoes in either Norway or Sweden, though slight shocks of earthquake have been experienced in both countries. But the rocks of which the Scandinavian peninsula is chiefly composed are the product of igneous forces, belonging to former geological periods. Gneiss and mica-schist are the prevailing rocks, both in Norway and Sweden. The bare elevated mountain plains of the former country consist principally of gneiss. Porphyry, greenstone, and other rocks of igneous origin, occur at intervals in Sweden. Granite is comparatively rare in both countries. The Scandinavian peninsula is geologically the oldest portion of Europe.*

Coral Islands.—Among agents of change in the relative proportions and superficial contour of land and sea, the labours of the coral-worm, or polype, require to be included. Within the warmer latitudes of the globe, and in each of the three great oceans, there are found a countless multitude of islands, which owe their existence, and constant growth, to this apparently insignificant member of the animal world. The coral-worm (of which there are several species, all exhibiting a certain general resemblance) secretes from the waters of the ocean, by its own natural economy, the stony material which constitutes its home, and which

* The proofs of the gradual rise and subsidence of land in Scandinavia are derived from the altered depths of the harbours at successive periods; the changed position of various marks along the line of coast; the presence at some distance inland, and at some elevation above the water, of shells identical with those now living in the Baltic, with other circumstances of like description.

is known to us as the coral-reef or island. The form most commonly exhibited by this polype is that of a little oblong-shaped bag of jelly, closed at one end, but having the other extremity open, and surrounded by tentacles, usually six or eight in number, set like the rays of a star. These tentacles, when stretched out, vary in length from four to six inches or upwards. Countless multitudes of these creatures are associated in the secretion of a common stony skeleton, the coral, or madrepore, the material of which coral islands are composed: the minute orifices of this rock constitute their dwelling-place, and when at work they may be seen beneath the water, protruding through these holes, and throwing out their tentacles in every direction; but when disturbed or molested in any way, they immediately withdraw, by sudden contraction, into their holes.

The coral islands and reefs of the Pacific are scattered through a vast area of that ocean, between the parallels of 28° on either side of the equator. They are more especially numerous within the latitude of 10° S. and the neighbourhood of the Southern tropic, and between the meridians of 134° west, and 135° east, of Greenwich. The multitudinous islands of Polynesia may, in fact, nearly all be brought under one or other of two great classes—those of volcanic origin, or of coral formation, and the latter compose by far the more numerous class. A great number of the volcanic islands, moreover, have coral reefs attached to their shores, and many are completely encircled by a belt of coral.

The Indian Ocean exhibits, in the long chain of the Maldive Islands, stretching through eight degrees of latitude, some of the most perfect examples of coral growth. Under the same meridian, the Chagos Islands, to the south of the equator, are of like origin. The Amirante Islands, in a more westerly part of the same ocean, consist entirely of coral, and the Seychelle group is based throughout upon a coral bank, though the islands themselves are of volcanic formation. Mauritius, again, is completely fringed by coral reefs, in which there are only two openings that allow of approach to its shores. The Red Sea abounds in corals, which stretch almost continuously along its shores on either side, and render its navigation in the highest degree dangerous.

The Atlantic Ocean furnishes fewer instances of coral-growth. The shores of Cuba, however, are thickly studded, through the greater part of their extent, with coral reefs, and

many of the smaller islands of the West Indies—especially within the Bahama group—are surrounded by coral. The Bermudas, in lat. 32° 20′, are entirely of coral formation, and form the south-eastern edge of an extensive bank of coral.

Excepting in the case of the Bermudas, the islands and banks of *living* coral are nowhere at a greater distance than 28° from the equator, and those islands are but a few degrees beyond the general limit. The coral-polypes, in fact, only inhabit the warmer belt of the globe, where the range of surface-temperature probably does not fall below 70° of Fahrenheit. The reef-building members of the family, moreover, appear to be only capable of living within moderate depths, not exceeding, at most, twenty or thirty fathoms; so that the islands which are composed of coral must have for their basis submarine formations of another kind. It is upon these submarine rocks—probably for the most part within a trifling distance below the surface—that the coral-worm commences its labours, and thence builds upwards until an elevation is reached over which the surf of the sea no longer washes, or which remains uncovered by the highest tides. The further labours of this marine architect are in a horizontal direction, since water is necessary to its existence, and they result in a continual increase of the limits of the reef which is in process of formation. Adjacent reefs thus become, in frequent instances, joined together, the shallow intervening channel being gradually filled up by the growth of the coral-rock.

The rate of increase exhibited by coral reefs is various, according, probably, to many differences of natural condition. In some cases it appears to be very rapid, an interval of a few years sufficing to produce a striking change in the aspect of coral reefs, and in the depth of the surrounding waters. In other cases, but little change can be traced within a considerable term of years.

Although it is stated that the reef-building corals only exist in comparatively shallow water, yet it is not denied that other members of the same family of polypes are to be found at much greater depths. Living coral has been brought up from 100 fathoms and upwards below the surface, and corallines may probably exist at depths as great as any within which animal life can be supposed to be maintained. The reef-building polypes, however, are well ascertained to be inhabitants only of the limited depths above mentioned. They include several species, and the structures which these

respectively rear exhibit characteristic differences. Some of them form large rounded masses, with numerous winding depressions, commonly known as brainstones;* some are studded with holes, filled with shelly plates placed perpendicularly, and converging to a point in the centre; others assume the appearance of a mushroom; the most common form is that of an irregular, branching shrub.

The most complete examination into the nature and growth of coral islands was that made by Mr Darwin, whose work has deservedly become a standard of reference on the subject.† Mr Darwin classifies all the various forms of living coral under the three headings of *lagoon islands* (or *atolls*)—*barrier* (or encircling) *reefs*—and *fringing reefs*. He regards the areas within which these formations occur as regions of gradual subsidence, and shows how the fringing-reef of coral which is found in so many cases attached to the coast-line of intertropical islands passes, by a gradual sinking of the entire area, into a barrier reef (that is, an encircling belt of coral-rock, with a channel of greater or less depth intervening between the coral and the main body of the island;) and the barrier reef into the condition of an atoll, in which coral only is visible, as the last vestige of the original formation disappears below the waters, and leaves only the encircling ring of coral, with an enclosed lagoon of still water. There is nothing in this theory in any way inconsistent with known truths respecting the physical condition of the globe, for, as we have seen, there are elsewhere regions, both of elevation and subsidence, exhibiting instances of slow and gradual action as well as of violent disturbance of the earth's crust.‡

* From the resemblance which the convolutions of the coral bear to the lobes of the human brain.

† On the Structure and Distribution of Coral Reefs. By Charles Darwin, M.A., &c. (London, 1841.)

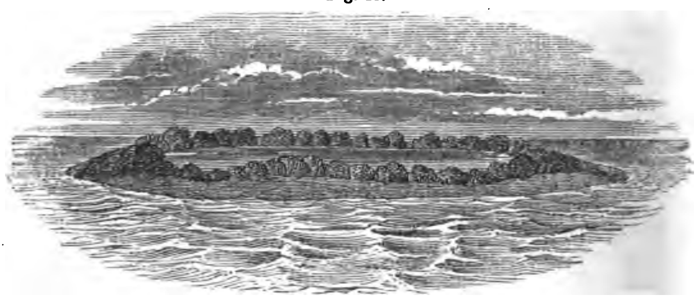
‡ The annexed diagram illustrates the manner in which, according to Mr Darwin's theory, the gradual transition in the case of a mass of coral rock, from the condition of a fringing-reef to that of a barrier or encircling

Fig. 14.

reef, and from the latter to that of an atoll or lagoon-island may be produced by subsidence. The lines A B, a b, and α β, are supposed to represent three successive levels of the sea surrounding (and, in the case of the last, covering)

The island-world of the Pacific furnishes examples of all three classes of coral formation. The atolls, or lagoon islands, are most numerous, and almost entirely compose the groups which are collectively known as the Low Archipelago, immediately to the eastward of the Society group. Both here and elsewhere, the islands of this class are generally of circular or

Fig. 15.



semicircular form, consisting mostly of a low belt or reef, which encloses a lagoon of smooth water, connected by one or more openings in the reef with the ocean outside. The form of an almost perfect circle is shown in the case of Whitsunday Island (S. lat. 19° 25′, W. long. 138° 35′), but the semicircular form is much more commonly met with. In such cases, the outer curve of the semicircle, that is, the convex portion of the reef, is invariably found to occupy the windward side of the island, the opening in the line of reef being always situated to leeward. In some cases, the coral-reef forms a complete ring, of circular or oval shape, and in others there is a double ring of coral, enclosing a lagoon of horse-

an island to which reefs of coral are attached. When the land and water occupy the relative levels indicated by the line A B, the island stands at some height above the waves, and the attached coral (*c*) is in the condition of a fringing-reef—*i.e.*, it skirts or fringes the coasts of the island. Supposing that, by subsidence of the land, the water subsequently occupies the place of the line *a b*, the coral (which during the process of subsidence, in virtue of well ascertained instincts on the part of the coral-worm, has continued to grow with most rapidity towards the *outer* edge of the reef, and to extend itself *upwards*, until the surface is reached) is then in the condition of a barrier or encircling reef, with an intervening channel between it and the body of the island. Suppose subsidence to continue until the water occupies, relatively to the land, the place of the line $\alpha\ \beta$, the coral (which has continued to increase in the direction of the surface) then forms a ring or belt, enclosing a lake-like expanse of water, or lagoon.

shoe shape. The reef always slopes gradually on its *inner* side, towards the lagoon, but rises abruptly from the deep bed of the ocean, on its outer circumference. The height of the reef above the water rarely exceeds a few feet, and portions are covered over at high water, or during storms.*

The island of Bolabola, belonging to the Society group, furnishes a striking example of a barrier-reef. A plan of this island is exhibited in the annexed cut. The island itself is of volcanic formation, and its highest point reaches 4026 feet above the sea. But it is encircled, at the distance of about a mile from its shores, by a belt of coral, between which and the island itself there is a channel of deep and still water. The reefs which similarly enclose Tahiti and others of the Society Islands, together with the islands of the Feejee group, and also those which nearly surround the shores of New Caledonia, are of this description.

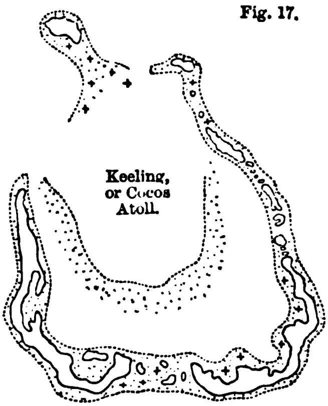
Fig. 16.

The shores of north-eastern Australia supply an example of a barrier-reef on a scale of vastly greater magnitude than is elsewhere found. Through a distance of more than twelve hundred miles in a direct line, from Cape York, at the northern extremity of the Australian continent, southward to Hervey Bay (S. lat. 24° 30′), the coast-line is everywhere fronted, at a distance which varies from ten or fifteen to a hundred miles, by a nearly continuous succession of coral reefs, lying only just below the surface of the water, and broken through in its upper portion by numerous narrow openings. These are collectively known as the "Great Barrier Reef." Between the reefs and the shore of the mainland, there is a channel, of moderate depth, which affords a safe passage for ships. Upon its outer side, towards the open ocean, the reef rises perpendicularly from a depth, on the average, of not less than 2000 feet.

* A few of the coral islands reach various elevations (from one to five hundred feet) above the sea. These have evidently been raised by volcanic agency, at some period subsequent to their original formation.

The reefs which surround the Sandwich Islands, in the North Pacific, and those of the Navigator and Friendly groups, in the southern half of that ocean (like those which encircle the island of Mauritius, in the eastern hemisphere,) are instances of fringing reefs. The Maldive and Chagos groups, in the Indian seas, are atolls, or lagoon islands. The Keeling (or Cocos) Islands, in the same ocean, are another example of the like kind.

Fig. 17.



Coral islands supply instances of change, the result of living agency, which is of high importance, when regarded as extending through lengthened periods. The reefs which the coral polype rears up to the level of the ocean become in course of time the habitation of man. The coral ceases to grow higher when they are no longer washed by the surf or rising tide, but it spreads in a lateral direction, and the height is gradually increased by various matter which the sea throws up during storms. The sun acts with intense force upon the newly-erected mass of rock, and under the combined influence of the atmosphere and the sun's rays the surface becomes gradually in greater or less degree pulverised into a covering of calcareous sand. The winds and currents bring the germs of vegetable and animal life, which are cast upon its shores. The cocoa-nut palm, especially, readily acquires a footing there. "Entire trunks of trees which are carried by the rivers from other countries and islands, find here, at length, a resting place, after their long wanderings; with these come some small animals, such as lizards and insects, as the first inhabitants. Even before the trees form a wood, the real sea-birds nestle there; strayed land-birds take refuge in the bushes; and at a much later period, when the work has been long since completed, man also appears, builds his hut on the fruitful soil formed by the corruption of the leaves of the trees, and calls himself lord and proprietor of this new creation." *

* Chamisso.

XII.

GEOGRAPHICAL DISTRIBUTION OF MINERALS.

The distribution of minerals constitutes an important chapter of Physical Geography, and one that is intimately connected with the advancement of nations and the industry of mankind. Countries are very variously circumstanced in this regard—some being as deficient in the more useful productions of the mineral world as others are in the precious metals, or the reverse. In the case of some regions, there exists comparatively little material for the exercise of mining industry, while in other instances (of which our own country furnishes the most conspicuous example) nearly every district has its characteristic mineral deposits or metallic ores.

Coal.—Of all the productions of the mineral world, *coal* is of most direct value to civilised man. This indispensable mineral is, fortunately, of tolerably extensive distribution, and the known area of its diffusion becomes continually enlarged by the extension of inquiry into regions hitherto only imperfectly known.* Two regions, however, greatly surpass any others in the extent and amount of produce of their coal-fields: these are, Great Britain, and the eastward division of the United States—both situated within the northern tem-

* The following Table, showing the estimated annual coal-produce of the world, is derived from a recently-published volume by Mr Hull, "The Coal-fields of Great Britain." (London, 1861):—

	Tons.
Great Britain and Ireland,	65,887,900
United States,	5,000,000
British America,	1,500,000
Belgium,	8,409,330
France,	7,740,317
Prussia and Austria,	4,200,000
Saxony,	1,000,000
Russia and other European States,	1,000,000
Japan, China, Borneo, Australia, &c.,	2,000,000
Total produce of the world,	96,737,547

perate zone. The first-named, though occupying by much the smaller area, is vastly superior to all others put together in the amount of its produce. The annual coal-produce of Great Britain exceeds 65,000,000 tons, which more than doubles the united produce of all the rest of the globe.

The coal-producing regions of Europe are—the British Islands, Belgium, France, Prussia and other parts of Germany (including Saxony, Bohemia, Hanover, and the Tyrol ;) with, in smaller quantity, Spain, Russia, and Sweden.

The extensive distribution, and vast importance, of the coal-fields of Great Britain are well known. The northern and midland counties of England, the southern counties of Wales, and the lowland division of Scotland, include the more important of the British coal-fields. Those of South Wales (906 square miles in area), Durham and Northumberland (460 sq. m.), South Yorkshire (760 sq. m.), South Lancashire (217 sq. m.), South Staffordshire (93 sq. m.), and North Staffordshire (75 sq. m.), are superior to any others in point of extent, and the regions of their occurrence coincide, as is well known, with the great localities of British manufacturing industry. The coal-producing districts of Ireland are of limited extent, though the carboniferous formation enters largely into the geology of that island. The produce of the Irish coal-fields amounts to less than one five-hundredth part of the total coal-produce of the British Islands. The total area of the British coal-fields is estimated at 2779 square miles.

Belgium ranks next to Britain in the amount of its coal-produce, which exceeds 8,000,000 tons annually. The total area of its coal-fields, however, does not exceed 520 square miles, chiefly within the provinces of Hainault and Liege.

The coal-fields of France are scattered over a wide area of that country, but are all of limited extent. The most productive is that in the neighbourhood of St Etienne, within the basin of the upper Loire. The total annual produce of the French coal-fields is above 7,000,000 tons.

Amongst the coal-fields of Germany, those of the Saar and the Ruhr valleys * (both within the Prussian territories), of Bohemia, Prussian Silesia, and Bavaria, are the most important. The Prussian coal-fields yield above 4,000,000 tons annually.

* The river Saar is an affluent of the Moselle, within the Rhine Province of Prussia : the Ruhr joins the Rhine on the east bank of that river, and chiefly within the limits of Westphalia.

In Spain—a country abounding in the most various mineral produce—the coal-fields are of considerable extent, but are little worked. Those in the province of Asturias are the most valuable.

The coal-producing countries of Asia comprehend India, China, Japan, Persia, Syria, Asia Minor, Burmah, and the island of Labuan, in the East Indian archipelago.

The coal-fields of India cover a considerable area, and already yield a large amount of produce—capable, it would seem, of considerable extension. The Raneegunge collieries (situated 126 miles to the N.W. of Calcutta, within the district of Burdwan) are more largely worked than any others. The coal deposits form a belt which stretches across the entire breadth of India, from the peninsula of Cutch on the west, to the extremity of Assam in the east, through more than 30° of longitude.

The little island of Labuan, situated off the N.W. coast of Borneo, and since 1846 a possession of Great Britain, derives its chief value from its abundant coal strata. The coal is worked through the agency of British capital, and Labuan has become a depôt for the supply of steamers navigating the eastern seas.

In Africa, the only coal known to occur on the mainland is within the valley of the river Zambesi, on the eastern side of the continent, where it has been lately found by Dr Livingstone. Good coal is said to occur in the island of Madagascar, where it is worked by the natives.

The coal-fields of North America come next to those of western Europe in point of value, and surpass them in point of extent. The coal-fields of the United States spread over an area of 196,800 square miles, and those of British North America (including Vancouver Island) cover above 7000 square miles.

Of the United States' coal-fields, the most important is the Alleghany or Pittsburg coal-field, which stretches through portions of Pennsylvania, Ohio, and Virginia, and the adjacent states. The town of Pittsburg, at the junction of the two arms of the Ohio river, is the Birmingham of the New World. The Illinois, Michigan, and Missouri coal-fields are each of great extent and value. The Richmond coal-field, in Virginia, which is of considerable value, is remarkable as belonging,

not to the carboniferous period of geologists, but to the limestones of the oolitic series.

Within British North America, the coal-fields of New Brunswick, and also those of Cape Breton and Prince Edward Islands, are of high value. Coal occurs on the western coast of Greenland, in lat. 70°, where it is worked by the Danish settlers, and also in several of the islands of the Arctic archipelago. Upon the opposite side of the continent, Vancouver Island has been found to contain valuable coal-strata, which, since the period of its colonisation by Britain, have been profitably worked, and promise to become of high importance in connexion with the growing steam-navigation of the North Pacific. In South America, Chili contains coal, the beds of which are worked to a considerable extent, and are of increasing value. In the West Indies, coal occurs in the island of Cuba, in the neighbourhood of Havanna.

In Australia, the colony of New South Wales includes a valuable coal-field, within the valley of the Hunter River, to the northward of Port Jackson. Good coal is also worked in Tasmania. The same valuable mineral occurs in several places in New Zealand, both in the north and the middle islands.

IRON, the most indispensable of metallic substances, is of even wider distribution than coal. There is, happily for man, no production of the mineral world which has such wide geographical limits. In one or other of its various forms, iron-ore occurs in nearly every region of the globe, and in connexion with formations which hold widely-distant places in the geological series. In our own country, the carboniferous series of rocks are the great seat of the iron workings of the present day; but the same metal enters extensively into other stratified formations, occurring abundantly among the limestones of the oolitic series, the wealden group, and elsewhere. It is within the carboniferous area, however, that iron can be most profitably worked, from the occurrence there, in immediate proximity, of iron, coal, and lime—that is, of the ore, the fuel, and the necessary flux or medium for the conversion of the ore into the workable metal.

Of European countries, those which furnish iron in the greatest abundance are Great Britain, Belgium, France, Russia,

Germany, Sweden and Norway, Italy, and Spain. The quantity of iron produced annually in Great Britain and Ireland is upwards of 3,500,000 tons, which exceeds in enormous ratio the supply furnished by any other single country, and is probably equal in amount to that supplied by all the other countries in the world, taken together. Belgium—rich in iron as in coal—supplies annually about half a million of tons.

The iron deposits of the Scandinavian peninsula possess a high degree of value, and the Swedish iron yields the best steel in the world. In Russia, iron ore occurs extensively in widely-distant parts of the great plain, and also within the southwardly portion of the Ural Mountains. The province of Styria (Austrian Germany) furnishes a large quantity of iron of excellent quality, equal to any that is made in Europe. In the south of Europe, the iron-mines of the island of Elba have been worked during the last two thousand years.

In Asia, iron is distributed over a vast area. Asia Minor, Georgia, Armenia, Persia, India, Siberia, Japan, and some of the islands of the Eastern Indies, all furnish it, in greater or less proportion. The iron-workers on the north-eastern coasts of the Lesser Asia, along the shores of the Black Sea, follow the same occupation now that their ancestors did in the days of Xenophon. In India, iron is worked in many parts of the Carnatic, and also on the Malabar coast: it occurs likewise in Northern India, within the elevated region of the Himalaya.

Iron occurs in widely-distant localities of the vast African continent—from the Atlas region in the north (where it is worked within the French province of Algeria) to the Cape Colony and the regions bordering on the Zambesi, in the south and south-east.

In the New World, the iron produce of the United States is of high value, and is greatly superior in amount to that of any other country, excepting Britain. The district within which it is principally worked coincides with that of the more considerable coal-fields. Canada, in the western division of the province, and especially to the north of the great lakes, is a country of rich mineral produce, iron being among its stores of native wealth. New Brunswick, Nova Scotia, and Cape Breton Island, also contain iron-ore.

In South America, Brazil, New Granada, Bolivia, Chili, and La Plata, are enumerated among the countries in which iron exists, though as yet it is nowhere worked to any advantage.

Australia has iron-ore distributed through an extensive re-

gion, embracing parts of New South Wales and Victoria, with the neighbouring island of Tasmania. It has not hitherto, however, been turned to any available account. New Zealand also contains workable ores of this metal.

COPPER is found in Europe chiefly in the following countries—British Islands, Spain, Russia, Hungary, Sweden and Norway, Turkey, and Germany.

In Great Britain, it is principally in the counties of Cornwall and Devon that copper is worked. The island of Anglesea and other parts of Wales, with the Isle of Man, and the county of Wicklow, in Ireland, also supply some quantity. A vast quantity of copper-ore from other parts of the world is brought to Swansea to be smelted.

The copper-mines of Norway possess high value: those of Sweden are less productive now than formerly. Spain abounds in rich ores of copper, which occur in many parts of that country.

Of Asiatic countries, Asia Minor, Armenia, Siberia, India, China, Japan, Persia, and some of the East Indian islands, supply copper, but none of them in any considerable quantity. The copper of Japan, however, is of the finest description, and is used extensively in that country for works of utility and ornament: some also is exported thence to Holland.

In Africa, it is only in Algeria that copper is worked to any noticeable extent; but the ore is known to occur in widely-distant regions of that continent, both towards its northern and southern limits, and upon the eastern and western coasts to the south of the equator.

In North America, copper occurs abundantly in the western division of Canada, in the vicinity of Lake Superior, and the ore has of late years been derived to some extent from that region. In the southern half of the New World, Chili, Peru, and other countries adjacent to the Andes, contain abundant copper-ores, which are worked in Chili on a scale of great extent. The island of Cuba has also valuable copper-mines. The copper both of Chili and Cuba is an article of extensive import into Britain, the ore being brought to Swansea for the purpose of smelting.

South Australia contains, in the famous Burra-Burra mine (situated 90 miles to the northward of Adelaide) one of the

most important sources of natural wealth. The Burra-Burra copper-ore was formerly brought to Swansea to be smelted, but that operation is now carried on in the colony itself, and the metal exported, in its perfect state, to England. Copper occurs likewise in other parts of the Australian continent.

TIN, a scarce but valuable metal, is derived chiefly from the mines of Cornwall, and from the island of Banca, in the East Indies.

The tin of Cornwall has been worked from a very early period, and attracted the mariners of Phœnicia to the shores of Britain many centuries before the Christian era. The only other countries of Europe which supply tin, to any noteworthy extent, are Spain (where it occurs in the province of Galicia) and Bohemia.

The small island of Banca, lying to the eastward of Sumatra, abounds in tin-ore of the finest quality. It is extensively exported thence to Holland, to which country Banca belongs. Tin occurs also in other parts of the East Indian archipelago, and likewise in Burmah, Assam, and the Malay peninsula. Both Mexico and Peru, in the New World, supply a limited quantity of the same metal, as likewise does the province of Victoria, in the Australian division of the globe.

LEAD occurs more abundantly in Spain than in any other country of Europe. The Spanish mines, both of lead and other ores, have been worked from a very early period, and yielded a large supply under the Romans. The variety and richness of the ores of lead which are distributed throughout the Spanish peninsula are described as truly astonishing. Lead enters likewise into the native produce of Great Britain and Ireland, Carinthia (Austrian Empire), Bohemia and other parts of Germany, Hungary, Transylvania, France, Belgium, Norway, Portugal, and Turkey. The lead mines of Carinthia supply a pure and exceedingly valuable description of lead: those of Bleiberg (seven miles W. of Villach) are among the most celebrated.

In Asia, the countries producing lead are Siberia, Armenia, India, China, Siam, and Japan. The lead mines of Siberia are

chiefly within the district of Daouria, to the eastward of Lake Baikal.

In Africa, it is only in the region of the Atlas, within the French province of Algeria, that lead mines are worked; but the ore of lead is extensively distributed over other regions of that continent.

In the New World, lead occurs in the United States, also in Canada; and in most of the countries of South America, especially in Chili. Lead is also to be included amongst the various mineral wealth of the Australian continent.

ZINC,* in one or other of its two ores—calamine and blende—is supplied chiefly from the mines of England and Wales, Prussia and various parts of Germany, Belgium, Spain, the United States, and China.

QUICKSILVER, or mercury—a metal of extensive use in the arts, and distinguished from other metals by its fluid form (unless at lower temperatures than 39° *below* zero of Fahrenheit)—is of limited distribution in a native state. The mines of Idria, in the Austrian province of Carniola, and those of Almaden, in the province of La Mancha (Spain) furnish the chief supply of quicksilver derived from European sources. In Asia, both China and Japan possess quicksilver, and a considerable quantity was formerly imported into England from the former country. In the New World, Huancavelica, in Peru, was long the chief source whence quicksilver was derived, but within a recent period valuable mines of this metal have been worked in California.

* Zinc, which is one of the most extensively distributed of metals, is not ound in a native state. The two ores from which it is extracted are *calamine* and *blende*—the former an oxide, the latter a sulphuret of zinc. Calamine (from which the larger proportion of zinc is derived) is found in China, in Siberia, the United States, Hungary, Carinthia, Silesia, and France; also in our own country, as at Mendip, in Somersetshire; Matlock, in Derbyshire; Wanlock-head and Lead Hills, in Scotland, and other places. One of its chief depositories is Limburg, in the Netherlands. Calamine is often found as an accompaniment of lead. Blende, or the sulphuret of zinc, occurs in Wales, Derbyshire, Cumberland, and Cornwall, and also in various parts of the European continent. It is almost always found either in connexion with rocks of primitive formation, or in the compact limestones of the secondary series. Though now employed for a vast number of useful purposes, zinc was until a recent period disregarded, as comparatively worthless. Calamine, however, was used in the making of brass, which is an alloy of zinc and copper.

The mines of Almaden, in Spain, lie within one of the tributary valleys of the Guadiana basin; the metal is worked in veins of considerable thickness, which occur in the palæozoic rocks of La Mancha. Notwithstanding the operations actively carried on there for centuries, the depth hitherto reached does not exceed 150 fathoms: the principal vein has a thickness of from 30 to 50 feet. These mines furnish annually upwards of 1000 tons of mercury. The quicksilver mines of California rival those of Almaden in value.*

In California and other gold-producing regions, quicksilver is necessarily employed for the purpose of separating the gold from the quartz rock in which it is imbedded. There has hence arisen an increasing demand for this metal since the gold-discoveries of recent times. It has the property of uniting readily, as an amalgam, with nearly all the metals, excepting iron.

GOLD. Of the precious metals, gold takes the first place in importance. Prior to 1848, the gold-fields of Siberia supplied by much the largest quantity of gold, and those of South America (particularly Brazil) came next in order of value.† But the gold-fields of California, first discovered in that year, and those of Australia, discovered three years later, now far surpass any others in point of importance.

The gold-fields of California are situated within the valley of the river Sacramento, which, deriving its waters from the high chain of the Sierra Nevada, on the western side of the North American continent, and flowing to the southward through a long valley, between that mountain-range and a lower chain more immediately adjacent to the coast, enters the fine bay of San Francisco, in lat. 38°. The gold, derived in the first instance, and for several years succeeding its first discovery, from alluvial washings at the base of the higher ground, is now obtained chiefly by means of crushing the quartz rock in which the metal is imbedded. Here, as in

* The most productive of the Californian mines—known as the New Almaden mine, situated at San José, (50 miles S.E. of San Francisco,) has remained closed since 1858, owing to a legal question as to title. The adjoining mines of the same metal are, however, of increasing richness.

† Before the working of the Californian and Australian gold-fields, the total annual produce of gold was less than £10,000,000, of which the Siberian mines alone contributed about £4,000,000. The annual gold produce of the world has been more than trebled within recent years.

other gold-regions, the quartz forms an integral portion of the palæozoic rocks which compose the mountain system. The quantity of gold derived from the Californian gold-fields since the date of their being first worked has averaged above £12,000,000 annually.

The province of British Columbia, also situated on the western side of the North American continent, between the Rocky Mountains and the Pacific, owes its formation into a distinct colony (in 1858) to the discovery of rich gold-fields within the valley of the Fraser river, which enters the Pacific in lat. 49° 10′. The group entitled Queen Charlotte Islands, within the adjoining ocean, also contain gold.

The gold-fields of the great southern land—Australia—rival those of California in abundance of produce, and perhaps extend over a larger area. The province of Victoria includes the principal regions of auriferous deposit. The gold-fields of New South Wales are of much less value. But the auriferous region extends along the entire inland range of the cordillera of eastern Australia, through a range of six hundred miles. In the Australian gold-fields, as in the like instance of California, the first workings were confined to the alluvial deposits, but as these are gradually being exhausted, the process of quartz-crushing has to be resorted to. The Australian Alps, with other portions of the prolonged mountain-cordillera of which they form a part, consist chiefly of palæozoic rocks, among which the quartz occurs in veins.

Within Europe, the countries whence gold is chiefly obtained are Transylvania and Hungary. The gold-mines of the Ural Mountains, with one exception, are all situated upon the Asiatic side of the chain. Small quantities of gold are obtained from workings situated within the higher Alpine valleys, chiefly upon the Italian side of the mountain-region; also from the Spanish peninsula, and from the group of the Wicklow Mountains, in Ireland: but the total value of these sources of produce is extremely trifling.

In Asia, Siberia ranks first in importance as a gold-producing region. Both the Ural and the Altai are regions of auriferous deposit, but the gold-mines of the Ural are in great measure worked out, while those of the Altai region are increasing in importance. The gold-fields are chiefly within the high grounds that divide the upper courses of the three great Siberian rivers—the Obi, Yenesei, and Lena,—embrac-

ing especially the valleys watered by the smaller tributaries of the two former streams. The gold-produce of this region averages £3,000,000 sterling annually.

Tibet, China, Burmah, Siam, the Malay Peninsula, Cochin-China, Tonquin, and Japan, with Borneo and some other of the islands of the East Indian archipelago, are also to be enumerated among the gold-producing regions of Asia. The gold-mines of Borneo are worked by the Chinese settlers on the west coast of the island, under the direction of the Dutch.

Africa has gold for its most characteristic article of mineral produce, but the quantity derived thence in the present day is trifling in point of value. Both the eastern and western coasts, within the tropics, supply gold—chiefly in the form of sand. Some of the tract of interior Soudan, between the head-waters of the Niger and Senegal rivers, are also rich in this metal.

In the New World, besides the valleys of the Sacramento and the Fraser, the gold-producing regions include Mexico and Central America, with Brazil, New Granada, Bolivia, Chili, and La Plata. The mines of Mexico, Peru, and Brazil, long furnished the chief supply of the precious metals to the rest of the world, but comparatively few of them are now worked to any advantage. The annual gold-produce of Brazil is little more than a quarter of a million sterling in value in the present day.

SILVER is frequently found in combination with other metals, especially with copper and lead. Most of the lead mines in our own country furnish a greater or less quantity of silver. The principal countries which furnish silver, in its native state, are—in *Europe*, Hungary, Bohemia, Transylvania, Saxony, Hanover, Turkey, Norway, and Spain.* In *Asia*, Siberia and China: in the *New World*, Mexico, Peru, Bolivia, New Granada, Chili, and La Plata.

Peru and Mexico furnish, in the present day, by far the greatest quantity of native silver. Potosi, (in the modern

* The mines of Spain anciently yielded the chief supply of silver, as well as of copper and lead, to the Romans. The enormous heaps of slag, known as Roman scoriæ, the refuse of their works, still contain a sufficient quantity of silver to pay for their working. In England, similar accumulations in the Mendip Hills (originally *Myne Deeps*) are smelted for the sake of the silver they contain.—*Official Cat. of Great Exhibition*, 1851.

state of Bolivia,) the mines of which were long so celebrated, is now of little or no value in this regard, but a vast number of mines are worked in other parts of the great mountain region.

PLATINUM, a valuable and scarce metal, is chiefly derived from mines in the Ural Mountains, where, however, it has been worked only since 1824. It occurs also in South America, in parts of Brazil and New Granada, and likewise in Spain. It is only in Russia, however, that it is used to any noteworthy extent.

The complete list of metals known to modern science comprehends not fewer than forty-three distinct substances. By far the greater number of them, however, are of rare occurrence, and of exceedingly limited utility, as compared with the few that have been noticed above. Among those that rank next in point of general utility, bismuth, antimony, manganese, nickel, cobalt, and arsenic, may be mentioned. Bismuth, a scarce metal, chiefly employed for the purpose of alloys, (as pewter, &c.,) is principally derived from Saxony. It occurs also in Siberia, and, to a small extent, in Cornwall. Antimony, which is employed for like purposes, and especially in the composition of type-metal, is supplied by France and Hungary. It occurs also in Spain, and both in England and Scotland. Of late years, however, the province of Sarawak, on the north coast of Borneo, has proved the largest source of supply. Manganese is derived from Devon and Cornwall, in our own country, and from various portions of Germany, (within the mining districts of Saxony, Hanover, and elsewhere,) also from Hungary and France. Nickel (employed in the manufacture of German silver, and in various other forms of alloy) occurs in Saxony, Bohemia, France, and Cornwall. Cobalt—employed in a great number of manufacturing processes, for the sake of its colouring qualities—is derived from several ores, which are found chiefly in Spain, France, Saxony, Bohemia, and other parts of Germany, and also in Cornwall. Arsenic, in its native state, is chiefly derived from Germany, (principally the mining districts of Saxony and the Harz,) Hungary, Transylvania, Siberia, and France.

SULPHUR, one of the most valuable of combustible minerals, is derived chiefly from the island of Sicily, where it occurs in vast abundance. It occurs, however, in various countries, within either division of the globe, and especially within volcanic regions. Sulphur is found abundantly in Spain, where it occurs under all its different conditions—native, earth-combined, and in sulphuric nodules. GRAPHITE (from which the so-called black-lead pencils are made) comes under the same division of the mineral kingdom.* It is an exceedingly valuable and rare mineral, nowhere else found of quality equal to that in the valley of Borrowdale, in Cumberland, immediately to the south of Derwent-water, where it occurs in a bed of trap rock alternating with clay-slate. Graphite, however, occurs in many other countries, both in the Old and New World.

The *diamond*, first in order of value amongst precious stones, is ranked by the mineralogist amongst combustible minerals, since it is really pure crystallised carbon, inflammable at a very high temperature. It is from Brazil that diamonds are chiefly derived in the present day. The districts of India which formerly yielded this brilliant gem have long since been nearly exhausted. Diamonds are still found, however, in some parts of that country (chiefly in the Bundelcund); also in Borneo, and (of small size) in the Ural Mountains.

Of other precious stones, the emerald is chiefly derived from Peru and some of the neighbouring countries of South America; the ruby from Burmah, and also (more rarely) from Ceylon; the amethyst and topaz, from Ceylon and China; the turquoise, amethyst, jasper, topaz, cornelian, and others of less value, are found in various parts of India, Turkestan, and among the mountainous tracts adjoining the Altai and Himalaya systems, as well as in the like regions of Russia, Hungary, Transylvania, and other parts of Europe.

SALT. Of all the various substances which compose the

* Though bearing, in popular language, the synonyms of plumbago, or black-lead, graphite has really not a particle of lead in its composition. It consists chiefly of carbon, mixed with a small proportion of iron.

mineral kingdom, there is none that enters more into the supply of the daily wants of man than common salt, which is a compound of soda and muriatic acid. The ocean, in which it everywhere exists in solution, is the great reservoir of this indispensable substance. It occurs, however, in the form of a solid mineral, over vast areas of the globe, and is also extensively obtained, in Britain and other countries, from brine-springs. In England, the great supply of salt is obtained from the new red sandstone formation, within the valley of the river Weaver, in Cheshire: to a less amount, but under like geological conditions, from the neighbourhood of Droitwich, in Worcestershire. The salt-mines of Bochnia and Wielicza, in Austrian Poland, or Galicia, are among the most famous in the world, and furnish a large supply. The tract of the Lower Steppes, in the south-eastern portion of European Russia, exhibits a soil which is largely impregnated with salt, and the small lake of Ielton, in the adjoining district, to the eastward of the Volga, supplies a large portion of the consumption of the Russian empire. The Salt Desert of Persia exhibits, over an area which embraces many thousand square miles, a saline efflorescence covering the ground, and causing it to sparkle in the distance. There are like tracts in other parts of the world, which have been elsewhere referred to. On the coasts of Spain, Portugal, France, and numerous other countries within warm latitudes, there are extensive *salines*, from which salt is obtained by evaporation from the water of the sea.

XIII.

DISTRIBUTION OF PLANTS.

THE distribution of vegetable life over the earth's surface is in great measure regulated by the various conditions of physical geography that have been described in the preceding chapters. Light, heat, and moisture, are necessary (with few exceptions) to the development of vegetable life, and the various measure in which they are combined serves in no small degree to regulate the capability of any region for particular kinds of culture. Thus, the combined heat and moisture of tropical countries favours the luxuriant development of forms of life which only attain a diminutive growth beneath colder skies. The more arid regions of the earth are the seat of a vegetable growth which is altogether distinct from that proper to moister regions; and this, again, differs in the case of aridity combined with heat from that of the same aridity under colder latitudes. The lengthened periods of alternate light and darkness proper to the climate of polar regions are attended by correspondent peculiarities in the classes of plants that are adapted by nature to such conditions of growth.

Irrespective, however, of any considerations concerning the peculiarities of vegetable organism, the influence of climate upon plants is sufficiently obvious, and is illustrated in numerous instances which are familiar to common observation. The flora* of the torrid zone differs widely from that of the temperate regions of the globe; that of the temperate zones from the vegetable growth of polar latitudes. But this mere division of the earth's surface into astronomical zones is insufficient to express the generalised truths which the transition in the forms of vegetation, from the heat of the equator

* The word *flora* is used to express the vegetation of any particular region; the parallel term *fauna* indicates its animal life.

to the cold of the polar regions, embodies. Adopting as their designations such terms as express, in a general manner, the distinguishing characteristics of their vegetable forms, we may divide the space between the equator and either pole into—

1. A zone of Palms and Bananas, reaching from the equator to about the parallel of 15° (mean distance.)
2. A zone of Evergreen Trees, extending from the parallel of 15° to that of 40° in the northern, and 35° in the southern, hemisphere.
3. A zone of Deciduous * Trees, reaching (as a mean) from the 40th to the 55th parallel in the northern half of the globe, and from the 35th to the 48th parallel in the southern hemisphere.
4. A zone of Conifers † and Edible Berries, reaching from the parallel of 56° N. lat. to the Arctic circle.
5. A zone of Mosses and Lichens, reaching northward from the Arctic circle towards the pole.

The dividing lines between the above zones are coincident with isotherms rather than with parallels of latitude, for, as we have elsewhere seen, temperature is dependent upon various conditions besides mere distance from the equator.‡ The zones themselves hence constitute so many waving bands which stretch round the globe, rising or falling to greater or less distances from the pole in the same way as the isotherms themselves.

The *first* of the above zones, which has a mean temperature varying between 82° and 77°, may be regarded as the natural region of the palms and bananas, together with tree-ferns and arborescent grasses (as the sugar-cane, bamboo, &c.); also of the coffee-tree, and of cocoa, cinnamon, and spices in general.

* That is, plants which cast their leaves annually: Latin, *decidere*, to fall.

† That is, trees of the pine and fir tribe. The conical form of the fir-apple, common to that family of trees, illustrates the meaning of the term.

‡ A division of the surface of the globe into a certain number of isothermal bands, each inclusive of characteristic forms of vegetable growth, was first proposed by the illustrious Humboldt, more than half a century since. The data accumulated during the subsequent period have added to the precision of detail, without affecting the truthfulness of generalisation, by which the views of that philosopher—the creator of physical geography as a science—were distinguished.

The *second* zone, within which the mean temperature undergoes a gradual decrease from 77° to 60°, includes the true region of the vine and the olive, the orange, the lemon, and the fig. It embraces, besides, the region of cotton and indigo, and (in Asia) that of the tea-plant. Palms occur, in either hemisphere, within the equatorial half of this zone, and only gradually give place to such evergreen foliage as characterises the Mediterranean shores of the European continent, which fall within its limits.

The *third* zone exhibits a decrease of mean temperature from 60° to below 50°. It includes the regions within which wheat and other cereals of temperate climates flourish, together with that of the apple, pear, and chestnut trees, also the proper regions of hemp and flax.

The *fourth* zone, within which the temperature falls from 45° or 50° to 32°, comprehends the native region of the pine, birch, willow, and other hardy members of the forest; with edible berries and the hardier grains, as barley and oats. It passes, in Europe, considerably beyond the line of the Arctic circle, but sinks in the Asiatic continent nearly to the parallel of 60°, and even lower on the eastern side of North America.

The *fifth* zone, in which a mean temperature lower than the freezing point is combined with a brief period of excessive summer heat, is the region of mosses and lichens, with dwarf-shrubs and alpine plants in general.

Successive belts, correspondent to the above in the essential characteristics of their vegetable growth, may be marked out in the direction of altitude, in the case of any of the elevated lands within the warmer latitudes of the globe. This truth has been already remarked on, in the chapter which treats of climate.* A high mountain-chain, situated within the tropics, presents an epitome of the successive climates, and (speaking generally) of the successive forms of vegetable growth, which belong to an entire hemisphere. The magnificent forms of tropical foliage found at the mountain's base are succeeded, at a moderate elevation, by the forest of evergreens; at greater heights, these latter are gradually supplanted by trees of the deciduous kind (oak, ash, lime, alder, &c.); yet higher in ascent, and the last-named give place to the pine-forest, which itself (dwarfed and stunted towards the mountain-summit) passes into a diminutive growth of alpine

* Page 136.

shrubs and yet smaller forms of vegetation. In many instances, not merely the genera, but even the specific forms, of Arctic vegetation are found at the summits of a mountain-region within the tropics. The reindeer moss of the polar regions is found on the summits of the mountains of Guiana, at a distance of only 4° from the equator, and appears indeed, at certain elevations, to be dispersed all over the globe.*

But the above considerations, important in regard to the influence of climate upon plants, and the capabilities of particular regions for the growth of certain species, are altogether insufficient to account for the distribution of the different forms of vegetable life. Every region of the earth has its own particular *flora*, some, at least, of the members of which are confined within a limited range, and are indigenous only to certain localities. This is true not merely of regions of considerable extent, but of districts of comparatively limited area. The distinction between the native flora of adjacent regions is often strongly marked. The forms of vegetation that are found upon opposite sides of a mountain-chain, or even any moderately-elevated tract of ground, often exhibit obvious points of difference.

No truth, indeed, in the records of the natural world—alike in regard to vegetable and to animal life—is more obvious than the fact that particular regions of the globe are to be regarded as distinct centres of organic being, each of them constituting the seat of certain genera of plants or animals. The plants that are indigenous to correspondent latitudes of the Old and New World are, with few exceptions, of different genera, and the same thing is true of animal life. Even where the same genus, or family, is represented, the species† differ. Again, within correspondent latitudes, and under at least a general similarity of conditions of climate, the native plants and animals of the northern and southern

* Schomburgk, in Journal of Royal Geographical Society, vol. x.

† The term "species" is applied (both in the vegetable and the animal world) to any assemblage of plants or animals which may be assumed to have sprung from a common stock. Individual differences between members of the same species—such as may be supposed to have arisen from different conditions of climate, food, or mode of nurture—are classed as "varieties." A number of species, possessing certain characteristics of organisation in common, constitute a "genus" or family. Thus, in the vegetable world, the various heaths constitute a single genus, but embrace a vast number of distinct species. In the animal world, the lion, tiger, ounce, and other animals, are included within the same family as the common domestic cat, but are distinct species. When any particular species is found *only* within a certain tract of country, (in a wild state,) it is said to be *peculiar* to that region.

hemispheres are in like manner different, and in even a more strikingly marked degree. And the difference in this latter case extends, not merely to species, or even genera, but to orders. Whole families of plants which are native to certain countries on the northern side of the globe, are wanting within the correspondent latitudes of the opposite hemisphere.

Let us note a few popular instances of these truths. As to food-plants: the cereals most generally grown in Europe—wheat, barley, rye, and oats—are indigenous only to the Old World, and were unknown to the natives of America until after the discoveries of Columbus and his successors. Rice—the chief food of a large portion of mankind—is native only to the countries of southern Asia. Maize, or Indian Corn, on the other hand, is an indigenous production of the New World. The potato—now the most widely-distributed of plants—was among the gifts of nature to the people of the western world, and was unknown to the rest of mankind until the 16th century. The same thing is true of the tobacco-plant. The tea-plant is indigenous only to south-eastern Asia and the neighbouring islands of Japan. The manioc-plant, which furnishes the cassava-bread of the Indian, is peculiar to the western half of the globe. The vine is indigenous only to the Old World, though long since introduced by man into the American continent, and, more recently, into the countries of the southern hemisphere. The bread-fruit tree of the Polynesian islander is native only to that region. On the other hand, scarcely a single one of the food-plants that belong to other regions of the globe is found amongst the indigenous productions of Australia.

These differences have not resulted from conditions of climate. In regard to the cereals, and similarly in regard to a vast number of the plants belonging to other divisions of the vegetable kingdom, a mutual interchange has been made between the productions of the Old and New World. Under favourable conditions of soil and climate, the plants originally confined to one hemisphere are found to flourish equally well upon the other side of the globe. Rice is now grown, upon the most extensive scale, within the warmer latitudes of the North American continent, as wheat and other European cereals are within its more temperate regions. Maize has been transplanted to the Old World, and flourishes through an extensive zone of the European and Asiatic continents. The vine has been carried from Western Asia to all

regions of the Old and New World alike which possess a temperature favourable to its culture, and now grows luxuriantly in the colonised portions of the Australian continent—a region into which it has been introduced only within the last three-quarters of a century.

These instances, derived from food-plants, may be paralleled in the case of every division of the vegetable world. The species of plants which inhabit the south temperate zone are different in nearly every instance from those belonging to the correspondent zone of the northern hemisphere. Of the family of heaths, which is spread over the whole of Africa, nearly the whole of Europe, and a portion of Asia, not a single species is a native of America. Of nearly three thousand species of flowering plants which are indigenous in the United States, fewer than four hundred are found in Europe. Of plants found in the mountainous parts of Equinoctial America, only twenty-four species are known to belong also to the Old World, and those are chiefly grasses. Again, out of 4100 species of plants found in Australia, only 166 are common to Europe, and most of this number are cryptogamous.*

If originally confined, however, to certain stations, both plants and animals have a natural tendency to extend their habitation over adjoining regions, and in numerous instances the same species have hence become distributed (even without the agency of man) over wide tracts of country—sometimes over geographical regions which are at considerable distances apart, and far removed from their native centres of growth. In the case of plants, the winds and currents are powerful agents in favouring such natural distribution. They carry the germs of vegetation over wide spaces of the earth, casting upon the shores of one region the seeds of fruits and flowers, and even of the larger forms of vegetable life, which originally belonged to another locality. It is in this way that the coral-islands—bare when first reared up to the surface of the ocean—become gradually clothed with vegetation. The cocoa-nut palm, one of the most valuable gifts of Providence to man, has in this way nearly made the circuit of the globe, within certain parallels. The sea, and the moisture which

* Plants are divided, with reference to their powers of fructification, into phanerogamous and cryptogamous. The former, which form the greatly more numerous class, include all flowering plants. The latter, having no flowers, produce no true seeds, but certain minute *sporules*, which take the place of seeds. The mushrooms, mosses, and ferns, are familiar examples of cryptogamous plants.

the atmosphere acquires while traversing the ocean, tend alike, in the case of seeds, to preserve their powers of generation uninjured. The intense heat of the desert, on the contrary, often destroys the vitality of seeds. A great expanse of arid land hence constitutes a more formidable barrier to the passage of vegetable forms than the vastest of oceans. It is from this cause that we find so wide a difference between the indigenous vegetation of the opposite extremities of the African continent. Its immense Sahara, or desert, intervenes to prevent the passage of the forms of life which are native to the regions that stretch beyond, upon either hand. Many of the plants that belong to the Mediterranean coasts pass the generally-moderate elevations of the Atlas, and are found upon its southern slopes, towards the border of the desert; but hardly a single one of them passes that barrier. Central Africa hence exhibits totally distinct forms of vegetable life; and the extreme south of the continent—at the same distance from the equator as its northern extremity, and under nearly correspondent conditions of temperature—displays differences yet more widely marked.

There is, speaking generally, a nearer approach to identity between the plants and animals native to very high latitudes of the Old and New Worlds, within the different continents of the northern hemisphere, than is elsewhere the case in regard to the flora and fauna of different regions. Within and near the arctic circle, the continents make comparatively near approach to one another; thence to the southward they diverge more and more widely, and within the southern hemisphere they are divided by spaces of vast extent. In the one case, the geographical distribution of land assists the propagation of species through adjacent tracts of wide extent, and under the same parallels: in the other, the species remain, with comparatively few exceptions, restricted to their original centres. The native plants of the Australian continent are, in every instance, peculiar to that region; but upon its northern and north-western coasts, there are found the palms of the adjacent Indian archipelago, together with many other plants that are obviously derived from the same source.

The flora of islands often exhibits very marked distinctions from that of the nearest continents, notwithstanding the tendencies to distribution above referred to. In the group of the Canaries, out of 533 species of flowering plants, 310

are peculiar to the islands themselves, only 223 being common to them with the African mainland. Of 33 native species belonging to St Helena, only two are found elsewhere. In the Galapagos Islands, there are hardly any species common to the South American continent; and, what is more remarkable, certain species are restricted to particular islands of the group, though the whole are but at short distances apart. In the Seychelle Islands, the large double cocoa-nut, called Coco de Mer, is restricted to two or three of the group, and is peculiar to that locality.

The most important agent in the distribution of species—in the cases of the vegetable and animal world alike—is Man. The plants and animals which are indigenous to the Old and New Worlds, or to particular regions of the northern and southern hemispheres respectively, have been carried by man to localities widely removed from their native habitation, and the changes thus effected daily receive greater extension with the increase of colonisation, and the continually-extending range of commercial intercourse. The orange, the vine, the fig, the peach, and the numerous varieties of the plum tribe, all derived originally from the northern hemisphere, and indigenous only to the countries of the Old World, have become naturalised on the opposite side of the globe, and thrive luxuriantly in the Australian soil. The forest-trees of our English and other European woodlands have been similarly transplanted to that distant region of the globe. Within the adjacent island of Tasmania, the common scarlet geranium (itself originally derived from Southern Europe) now covers whole tracts of country, and reminds the English settler of his former home. The common Scotch thistle, previously unknown in that division of the globe, has propagated so extensively in South Australia as to create alarm to the agriculturist, and to compel the attention of the colonial legislature, with a view to the adoption of measures to check its growth. On the other hand, most of the fruits and flowers which are now among the common objects of our gardens and orchards have been originally derived from foreign sources—a large proportion of them from Western Asia. We owe to that region the peach, the cherry, and the principal varieties of the plum tribe; with, among flowers, the narcissus and numerous other bulbs, the ranunculus, and many of the choice varieties of the rose.

It is therefore necessary for the student of physical geo-

graphy to bear constantly in mind the distinction between the *indigenous flora* of a country, and the *existent vegetation* (often very widely different) which it exhibits in the present day. The one illustrates the geographical distribution of plants according to their localities or original habitation; the other is in great measure dependent upon conditions of climate and soil, and has been more or less regulated by the agency of man.

Some of the plants which are specially distinguished by their utility to man are enumerated in the following list, (without reference to strict order of botanical classification,) with an indication of the geographical distribution of each :—

Wheat, *barley*, and *rye*, the principal cereals* of Europe, are all natives of the Old World, and have probably been derived originally from Western Asia. Wheat requires a warmer temperature than either of the other two, and does not attain perfection with a mean summer heat below 60°. Within the tropics, wheat only flourishes at such elevations above the sea-level as correspond in point of temperature to the sub-tropical and temperate zones. Barley thrives best with mean summer temperatures between 46° and 50°. Rye grows best within the boundary of wheat and barley, and is largely cultivated in the countries of northern Europe. Oats thrive within the same limits as rye. All of these grains are now grown within the suitable climates of the western world, and also under like conditions in the southern hemisphere.

Rice is also a native of the Old World, and is the chief article of food to the immense population of southern and south-eastern Asia, where it has been cultivated from the earliest ages. Rice requires a summer temperature of 73½°, and an abundant supply of moisture. Some species, however, flourish in colder and drier climates, as that known as mountain-rice, which grows on the sides of the mountains of Nepaul and upon the

* The term *cereal*, applied to the corn-plants, is derived from "Ceres," the name of the goddess of husbandry among the ancients. Besides those referred to above, there are several less important plants that come under this designation. Cereals comprehend all grasses of which the seeds are sufficiently large to be used for the food of man.

high plains of Tibet. Rice is now abundantly derived from the southern states of the North American Union.

Millet, of which there are several species, is another of the grasses native to the Old World. The kind most extensively used as food is that distinguished as panicled millet, (*sorghum vulgare* of botanists,) which is largely grown in Egypt and Nubia—where it bears the name of dhourra—in India, and in Cochin-China. In the West Indies, to which region it has been introduced, it is known as Guinea-corn. The species of this grain known as German millet and Italian millet are cultivated to some extent in Europe, chiefly as food for domestic poultry and horses.

Maize, or *Indian corn*, is the chief food-plant of the New World, to which it is indigenous. It belongs (like rice) to the tropical cereals, and requires a mean summer heat of 66°. Maize constitutes the most important corn-crop of the United States.* It is also now largely cultivated in the countries of central and eastern Europe.

Cassava, or *manioc*, which is largely used as food by the native Indian population of South America, is prepared from the root of the plant known to botanists as *Jatropha manihot*. It is indigenous to Brazil, Guiana, and the neighbouring parts of South America, and extends into the Mexican Isthmus. Tapioca, which is imported for use in our own and other European countries, is a kind of starch prepared from the farina of the cassava root. It is not a little curious that the root of the jatropha manihot, in its natural state, is highly poisonous. But the obnoxious juice in which the poison consists is expelled by means of pressure, combined with heat.

Potato. This valuable root, now so extensively distributed, is a native of the New World, and was first introduced into England in the latter half of the 16th century. It appears to be indigenous both in the northern and southern divisions of the American continent. The potato thrives in Iceland, and has become widely distributed over all the regions of the temperate zones.

* In the United States, by the word "corn" is always meant maize. The other cereals are spoken of by their distinctive names, as wheat, &c.

both in the northern and southern hemispheres. Within the tropics, it only thrives at considerable elevations above the sea.

Yam. This plant, the root of which forms a nutritious food, somewhat resembling the potato, and used as a substitute for bread, is indigenous to the Old World. In Ceylon, and on the Malabar coast, it is found growing wild in the woods. The yam was early carried to the West Indies, where it was extensively grown, as well as over an extensive range of Asia and Africa, within the tropics.

Arum, or taro, also an esculent root (*arum esculentum* of botanists, and commonly known as the wild Indian turnip), is the chief article of native food to the people of the Sandwich Islands. It is also a native of New Zealand and others of the Pacific groups.

Batata, or *Sweet-Potato*, another of the esculent roots, is native to the same regions as the arum.

The *Sugar-cane* is a native of China, Cochin-China, and the adjacent countries of south-eastern Asia, within which part of the globe it was earliest used for the purpose of making sugar. Thence it appears to have travelled to the westward, by way of India and Arabia, and to have been first introduced into Europe in the early part of the 15th century. Early in the succeeding century the cane was carried to the West Indies, where its culture has ever since been an object of prominent importance. It appears probable, however, that the sugar-cane already existed, in a wild state, in the western world. In the present day it is cultivated in every division of the globe within the tropics, but America (especially Cuba and Brazil) furnishes by far the larger quantity required for the supply of commerce.

The *Sugar-maple* is a tree native to Canada and other parts of North America. A considerable quantity of sugar is made from its sap, in Canada and elsewhere. *Beet-root*, a well-known vegetable, is extensively grown in France and other parts of continental Europe, for the same purpose.

The *Tea-plant* is indigenous to China and parts of the Indo-Chinese peninsula (Tonquin, Cochin-China, and Assam), and likewise to Japan. It is in China, however, that its cultivation is pursued upon the most extensive

scale, and it is thence that other countries draw their supply of tea, the use of which (only introduced into Britain within the last 200 years) has become so universal. The tea-plant is an evergreen shrub, growing to the height of eight or ten feet. There are two principal varieties of the plant, from each of which both the black and green teas are produced, according to differences in the local treatment of the leaves, as to time of picking, drying, &c. The culture of the tea-plant in China is restricted to the south-eastern division of China, between the 23d and 31st parallels, embracing Fokien and the adjacent provinces of Chekiang and Kiang-su. Attempts have been made to introduce the plant into other regions, of correspondent climatic conditions, as Brazil and elsewhere, but without much success, owing perhaps to the difficulty of obtaining the necessary supply of Chinese labour for the superintendence of its growth. The climate of Eastern Australia appears to be highly favourable to it.

The *Coffee-shrub* is a native of Abyssinia, in the wooded tracts to the southward of which country it attains the size of a forest-tree. It was early naturalised in the south-western province of Arabia (Yemen), and has thence become distributed throughout an extensive zone of either hemisphere. What is called the coffee-berry is really the kernel of the stone contained in the fruit which the shrub bears. In the present day Brazil, Central America, Cuba and other islands of the West Indies, in the New World, with Java, Ceylon, and Arabia, in the eastern half of the globe, furnish the chief supply of coffee.

The *Cacao-tree* (whence the cocoa and chocolate of commerce are derived) is a native of South America,* in all the warmer parts of which it grows, and also in Central America and Mexico. The cacao-tree reaches a height of about twenty feet, bearing large, oblong, and pointed leaves, with small flowers, of a pale red colour. The flowers are succeeded by pods, within which are the

* Chocolate, which is the Mexican name of the plant, is prepared from the kernels of the cacao-nut mixed with sugar, together with vanilla or other flavouring ingredients. The *Vanilla* is a creeping plant native to Mexico and other tropical regions of the New World, but extensively cultivated in other warm localities, as in Ceylon, Ré-union, and elsewhere.

seeds that constitute the cacao, or cocoa, of commerce.

The *Banana* and *Plantain* are varieties of the same plant, a native of the tropical regions of the New World. It flourishes throughout a zone (of either hemisphere) within which the mean annual temperature is not lower than 75°. The fruit of the banana contains a greater quantity of nutritious matter than any other production of the vegetable kingdom within like compass.

The *Bread-fruit tree* is a native of the islands of the Pacific Ocean, within warm latitudes, and has been transplanted thence to the West Indies. Its fruit supplies the chief article of food to the natives of Polynesia.

The *Cocoa-nut palm*—one of the most valuable of the numerous trees belonging to the palm tribe—is native to the warm and watered regions of both hemispheres. It abounds especially upon the islands and maritime regions of southern Asia, and throughout the Polynesian islands, to the inhabitants of which it is an indispensable necessary of life.*

The *Date-palm* is indigenous to the warm and arid regions of the Old World, and is invaluable to the scattered dwellers within the outskirts of the desert and the wanderers over its vast expanse. Its range extends from the region of the Atlas on the west to the plains of India in the opposite direction. Dates are extensively used as food by all the nations of Northern Africa and the south-western parts of the Asiatic continent. The date-palm flourishes in Sicily, and on the rock of Malta.

* "Year after year the islander reposes beneath its shade, both eating and drinking of its fruit; he thatches his hut with its boughs, and weaves them into baskets to carry his food; he cools himself with a fan platted from the young leaflets, and shields his head from the sun by a bonnet of the leaves; and sometimes he clothes himself with the cloth-like substance which wraps round the base of the stalks, whose elastic rods, strung with filberts, are used as a taper. The larger nuts, thinned and polished, furnish him with a beautiful goblet; the smaller ones with bowls for his pipes; the dry husks kindle his fires; their fibres are twisted into fishing-lines and cords for his canoes; he heals his wounds with a balsam compounded from the juice of the nut; and with the oil extracted from its meat anoints his own limbs and embalms the bodies of the dead. The noble trunk itself is far from being valueless. Sawn into posts, it upholds the islander's dwelling; converted into charcoal, it cooks his food; and, supported on blocks of stone, rails in his lands. He impels his canoe through the water with a paddle of the wood, and goes to battle with clubs and spears of the same hard material."

The *Oil-palm* (*elais guineensis*) is indigenous to the coasts of Western Africa. The oil, which is largely imported into England—chiefly for use in the making of soap—is expressed from the covering of a hard seed or nut.

The *Sago-palm* is a native of the islands of south-eastern Asia, and supplies an article of food which is largely consumed by the people of the Celebes, the Moluccas, and some of the adjacent groups. The sago of commerce is the pith of the tree.

The *Pandanus*, or *screw-palm*, which yields a juicy aromatic fruit, is indigenous chiefly to the Caroline Islands.

The *Cabbage-palm* is a native of tropical South America, also of Eastern Australia and other portions of the Pacific coasts and islands. It yields a fruit used as food by the native population of Guiana.

The *Coco-de-mer* is confined to the group of the Seychelle Islands.

The *Cotton-plant*, of which there are several species, varying in size from a small shrub to a tree of twenty feet in height, has perhaps been derived from India, of which country it is a native. But cotton is also indigenous to other countries of Asia, as well as to parts of the African continent; some species of it are native to the New World, within which the culture of cotton has been most extensively pursued in recent years. It requires a warm climate. The cotton is the soft downy substance in which the seeds of the plant are imbedded. The best kind, known as Sea Island cotton, is grown upon the coasts of North Carolina. The cotton-crop of the United States is of enormous value, amounting to upwards of £20,000,000 annually: the greater part of it is imported into Britain. The culture of cotton in British India is extending considerably at the present time. The maritime districts of Eastern Australia (Queensland and the adjacent portions of New South Wales) possess a climate admirably adapted to its growth.

Flax is the fibre furnished by the stem of the flax-plant, a native of the temperate regions of the Old World. European Russia, with Prussia, Belgium, and portions of Austria, furnish the chief supply of flax. It is also

largely grown in Ulster, for the linen-manufactures of that province. Linseed is the seed of the flax-plant.

Hemp is the fibre obtained from a plant of the nettle tribe, which grows within the temperate regions of the Old World, and is said to be a native of Persia. It is largely grown in European Russia, whence the chief supply is derived. Within recent years, the fibre of *jute*, a plant native to India, has in great measure taken the place of hemp in the English market. *Manilla hemp*, also a native Indian plant, belongs to a totally different species from common hemp, and is a member of the same genus as the banana.

Indigo is derived chiefly from British India: in much smaller proportion, from Central America. It is the dye obtained from the leaves of a small shrub of which there are numerous species, indigenous to various parts of regions within the warmer latitudes of both the Old and New Worlds.

Madder is obtained from the root of a plant native to central and western Europe.

Cochineal is the colouring-matter obtained from an insect which thrives only upon a species of cactus (*cactus coccinifer*) which is indigenous to Mexico and Central America. This plant has been successfully introduced into the island of Madeira within a recent period.

The *Cinnamon-tree*—the bark of which constitutes the cinnamon of commerce—is indigenous only to Ceylon. Other trees belonging to the same genus, but of different species to the true cinnamon, occur in parts of south-eastern Asia and the islands of the East Indian archipelago.

The *Clove* is a native of the Molucca Islands, and peculiar to that region. Its culture has, however, been introduced into the island of Ré-union, or Bourbon.

The *Nutmeg-tree* is also indigenous to the Moluccas, but is found in several other parts of the East Indies (Sumatra, &c.): it has been introduced into the Mauritius.* The nutmeg of commerce is the kernel contained

* The Dutch, actuated by the spirit of commercial monopoly, endeavoured to prevent the nutmeg and clove from spreading beyond the Moluccas, and even strove to extirpate the former from all the islands except Banda, in order to enhance the value of the nutmeg. It is said that the wood-pigeon

within the fruit of this tree: the spice known as *mace* is the membranous covering which immediately encloses the kernel.

Ginger is a native of south-eastern Asia and the adjacent islands. It was early introduced by the Spaniards into the New World, and is probably indigenous also to that side of the globe. It is extensively cultivated in Jamaica and other parts of the West Indies. The tuberous root of the plant supplies the ginger of commerce.

Pepper, of which there are numerous species, is found in every quarter of the globe excepting Europe. Both black and white pepper are the produce of the *piper nigrum* of botanists—a perennial plant, found native in India and the Indo-Chinese peninsula, and especially abundant on the Malabar coast. It is largely cultivated in Sumatra, Java, and the neighbouring islands. The leaf of the betel-shrub, one of the species, is used throughout southern Asia to wrap round the areca-nut, universally chewed by the native population of that part of the globe. Cayenne pepper is the pod of a species of capsicum, native to most tropical regions, dried and reduced to powder.

Pimento—the allspice of commerce—is supplied by the berries of a tree (*myrtus pimenta*) native to South America and the West Indies, and extensively cultivated in the island of Jamaica.

often became the unintentional means of thwarting this endeavour, by conveying and dropping the fruit beyond those limits. Owing to such agency, the nutmeg became more widely disseminated than the clove. This illustrates what has been said in a preceding page as to the distribution of plants (204).

XIV.

GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

THE great division of the animal kingdom recognised by naturalists is that into *vertebrate* * and *invertebrate* animals. Vertebrated animals are those which possess a spinal bone, to which are attached ribs, constituting the frame-work of the entire body. All animals of this division have red blood. The vertebrate animals comprehend fishes, reptiles, birds, and mammalia.† This last term is inclusive of all animals that suckle their young, comprehending the animals popularly known as quadrupeds, together with man himself.

The mammalia are divided into nine orders:—1. Carnivora (*flesh-eating*, as the lion, tiger, &c):—2. Ruminantia (*animals that chew the cud*, as the camel, ox, sheep, and others):—3. Pachydermata (*thick-skinned*, as the elephant, horse, &c.):—4. Rodentia (*gnawing*, as the beaver, squirrel, mice, &c.):—5. Edentata (*toothless*,‡ as the ant-eater and armadillo):—6. Quadrumana (*four-handed*,§ as the ape and monkey tribe):—7. Cheiroptera (having winged arms, as bats):—8. Marsupialia (*pouched*, as the kangaroo and opossum):—9. Cetaceæ (whales and dolphins). The last-mentioned of these divisions comprehends a class of beings which in popular language are assigned to a distinct division of the animal world—fishes. But the whale and other creatures of its order possess the

* *Latin*, *vertebra*, a joint of the spinal bone.

† *Latin*, *mamma*, a breast.

‡ Or, rather, wanting certain teeth, as the incisors or the canines.

§ In the monkey tribe, all four of the extremities possess the power of *grasping*, like that belonging to the human hand. Hence the term four-handed. The thumb-like joint, which gives this power, is developed in an eminent degree in the gorilla, or large ape recognised within recent years as inhabiting the forests of Western Africa, in the neighbourhood of the Gaboon river (0° 30′ N. lat.)

distinguishing attribute of the mammalia—that is, they afford their nutriment from the breast.*

The animals belonging to the ruminating and pachydermatous orders are further distinguished as *ungulata*, or hoofed, from the well-known characteristic of their extremities. The domesticated animals that are used as food by man are almost exclusively derived from this class. The animals included within the other orders of mammalia are designated as *unguiculata*,† from their extremities terminating in claws, or nails.

The invertebrate animals, or those which have no spinal bone, all have white blood. They are scientifically divided into *molluscous* animals, in which the muscles are attached to the skin, with or without the protection of a shell—such as snails and slugs; *articulated* animals, in which the covering of the body is divided into rings or segments, to the interior of which the muscles are attached—comprehending all insects and worms; and *radiated* animals, in which the organs of motion or sensation radiate from a common centre—such as star-fish.

What has been said in the preceding chapter respecting the distribution of vegetable life, in connexion with the various conditions of climate that are experienced in different regions, applies equally to the animal world. Isothermal lines mark—with hardly less precision in the case of animals than of plants—the range of particular families and species, in the direction of latitude and of elevation alike. The fact that such is the case testifies strongly to the force of those instincts with which all animals are endowed, and by which their habits are regulated. The powers of locomotion possessed by animals might at first sight seem calculated to favour a wider extension of geographical range than belongs to vegetables, and in the well-known instances of migratory species (of which the swallow and other birds are familiar examples) such is undoubtedly the case. But even these migrations are confined within a well-defined range, determined by conditions of climate, and facility of obtaining the necessary food. This is true not only of birds or quadrupeds, but of

* The young of the whale is always spoken of as a calf.
† *Latin*, *unguis*, a hoof: *unguiculus*, a nail.

every one of the great classes into which the animal world is divided. Each zone of the ocean, both in latitude and in the direction of depth, has its proper forms of life.

To take an instance from land-animals, the elephant is confined by natural instinct within the belt of the warm latitudes, and not more so by the high temperature which such latitudes alone enjoy than by the limitation of its necessary food to the regions which are its proper home. Nowhere else but within or near the tropics is there found the luxuriant abundance of forest vegetation which the elephant requires to make sustenance upon. The rein-deer, on the other hand, is as characteristically an inhabitant of polar latitudes, and perishes if brought within the continued influence of a warmer temperature than that of his native region. The ibex and the chamois, with some other animals of the goat tribe, frequent only the highest and least-accessible portions of the mountain-region, while various members of the deer kind range the lower elevations and the adjacent plains that are below. Of birds, the condor, or great vulture of the Andes, confines his range within the region of the highest peaks of the mountain-region, as his European congener—the lammer-geyer, or vulture of the Alps—does in another part of the globe. In the mountainous portions of our own island, the eagles which (notwithstanding the keen pursuit of the sportsman) still frequent the scarcely-accessible crags that surround Loch Maree and other secluded localities of the Highlands, furnish a similar instance. Again, the shark is the well-known scourge of the warmer belt of ocean, while the same zone of sea constitutes—from its high temperature—a region through which the whale never passes.*

It is, besides, equally true of the animal as of the vegetable kingdom, that every region of the globe has its own proper inhabitants, different in species, for the most part, from those of other regions. The animal life of the Old World is markedly different from that of the New World in correspondent parallels, and under conditions of climate which are in all important regards analogous. Even when the genera, or families, are the same, the species are in nearly all cases distinct. In yet higher measure, the animal life of Australia differs from that of other divisions of the globe. Whole *orders* † of the animal

* The whale of the northern seas, and that of high southern latitudes, are of distinct species.

† The terms *species*, *genus*, *order*, and *class*, are used in scientific zoology for

world are wanting in Australian zoology, while the vast majority of its animals belong to a division which is altogether unrepresented in the continents of the Old World—that is, the marsupial tribe. The difference is less strongly marked in the case of the adjacent continents of the northern hemisphere than in the instances of the lands lying south of the equator, and for reasons which (in the correspondent case of the vegetable world) have been elsewhere adverted to.

The natural distribution of animals has been importantly modified by human agency. This is especially the case in regard to those divisions of the mammalia which comprehend the domestic quadrupeds—the horse, dog, ox, sheep, and others. Man has carried these animals with him in his migrations from one region to another, and has thus introduced new species (and even genera) into lands where they were previously unknown. The horse, the ox, and the common sheep, were unknown in the New World prior to the Spanish discoveries of the fifteenth and sixteenth centuries, but speedily became naturalised there, and, in the case of the two first-named, have long since reverted to a condition of nature. Wild horses roam by thousands over the savannahs and pampas of the western world. Within a much more recent period, the domestic cattle of Europe have been introduced into the Australian continent, and have multiplied there to an extraordinary degree. Efforts are now making to introduce into Australia both the camel of the Old World and the llama of South America. Similar efforts are at the present time directed to the naturalisation in the Australian rivers of the salmon and other fish that belong to the streams and estuaries of Europe. What has been accomplished, in these and many similar cases, by the direct efforts of man, has resulted, in the case of many of the smaller animals, from his involuntary agency, or from accidental causes. The vessel

the purpose of classification. *Species* distinguishes animals that have sprung from a common stock; a *genus* includes such species as have certain attributes in common: several genera are comprehended within a single *order*, as the grouping together of certain orders constitutes a particular *class*. Thus the mammalia (animals that suckle their young) constitute one of the great *classes* of the animal kingdom. This class includes—according to the division universally recognised, that of the illustrious Cuvier—nine *orders* (ruminants, carnivora, quadrumana, &c.) Each of these orders comprehends numerous *genera*, as the various members of the cat tribe, &c.; and each genus includes numerous distinct species. In the case of animals, as of plants, differences which have resulted from accidental causes, such as are connected with climate, food, or general treatment, are classed as *varieties*.

which conveys a cargo of native produce from one region to a foreign shore has often carried with it the germs of life (vegetable as well as animal), besides, in numerous instances, the smaller members themselves of the animal world. The insects that were originally confined to one region have thus become distributed over wide areas of the globe.

A few other of the more obvious differences between the native zoology of the Old and New Worlds may be adverted to with advantage. Among *carnivorous* quadrupeds, the lion, tiger, leopard, panther, and hyena, are confined to the eastern half of the globe. In the New World, the puma and the jaguar take respectively the places of the lion and tiger of the Asiatic continent. Of the *ruminants*, the camel, the giraffe, and the numerous antelopes, are only found within the Old World. Of the *pachydermatous* order, the elephant, the rhinoceros, the hippopotamus, the horse, the zebra, and the ass, are unknown to the native zoology of the lands lying west of the Atlantic. The elephant, and also the rhinoceros, belong to Asia and Africa (the species being different in the case of either continent), the hippopotamus is African only: the zebra (with its kindred species, the quagga) is also peculiar to Africa. Both the horse and the ass probably came origiginally from Asia. Of the *quadrumana*, which are numerously represented in the zoology of either hemisphere, the species (and, in most cases, the genera) are distinct. Again, the opossums of the New World belong to an order (the *marsupial*) which is altogether unrepresented in the three continents of the Old World, but which exhibits its fullest development in the Australian division of the globe. Numerous other instances might be adduced, but these will suffice. They serve to show that, in the case of animals as of plants, particular regions constitute centres of particular forms of life, which thence spread, within certain limits, around, still leaving to each such region its strongly-marked and typical characteristics in such regards.

EUROPE exhibits, in its indigenous zoology, a character less marked and distinctive than belongs to other divisions of the globe. This is in some degree the result of its dense population, and the consequent diminution in the number of wild species, but in a more especial manner results from its con-

ditions of geographical form and position. Europe is less a continent in itself than an outlying portion of the vast and unbroken mass of the Asiatic continent. No strongly-marked feature intervenes between the plains of eastern Europe and those of northern Asia, and within the continuous range of land that extends, under the same parallels, from the Baltic Sea eastward to the waters of the Pacific Ocean, the animal life exhibits for the most part identity of species and genera. The differences between them, in a vast number of instances, are merely varieties. Many of the fur-bearing animals are common to all the lands that lie within the arctic circle, as many as twenty-seven species being native to Europe, Asia, and North America alike.

The vast population of Europe has necessitated the rearing of the domestic quadrupeds in vast numbers, and has been accompanied, in numerous instances, by the extermination of the wild denizens of the forest. It would seem from a passage in Herodotus (book vii., 125) that the lion once frequented the woods of Macedonia. The wild boar, the bear, and the wolf, were formerly natives of the British Islands, and the last-named animal has only been exterminated from within their limits during the last hundred and fifty years.* The beaver, long since banished, was once common on the banks of the Welsh streams. The fox is only preserved by artificial means, and for the purposes of the chase. The wild cat, now rarely seen, and that only in the remoter portions of the Scotch Highlands, was formerly common within the English forests. The bustard, a bird now rarely seen, was once met with in huge flights on the plains of Norfolk and Suffolk, while huge fen-eagles frequented the marshy flats of the adjacent country.

These are but a few instances of the way in which human agency modifies the distribution of animal life. On the continent, the extermination of a particular species is of course more difficult, in numerous cases is perhaps altogether impossible. The wolf inhabits the forests of continental Europe, from the high tracts that adjoin the Alps and the Pyrenees northward to the shores of the Baltic and White Seas. The wild boar and the bear (three species of the latter —the brown and black bear in the wooded regions of the

* Wolf-hunting was enumerated among the common sports of Kerry as late as 1719. The savage brood had been finally expelled from the forests of Great Britain during the preceding century (Macaulay, chap. iii. and xii.).

south, the white polar bear in the extreme north) are still met with. The urus or wild ox of the Lithuanian forests, regarded by naturalists as the progenitor of our common domestic cattle, is even yet found to the eastward of the Baltic.

Europe, however, has no one of the great families of mammalia that can be looked on as peculiarly its own, or, in other words, as giving it a distinctive zoology—like the antelopes of southern and western Asia, the numerous pachyderms of the African continent, the llama tribe of the New World, or the marsupials of Australia. Of the total number of European mammalia, not exceeding a hundred and eighty, only fifty-eight are peculiar to this continent, and none of the larger quadrupeds are included amongst them.

The domesticated animals that are so numerously reared in every part of Europe have probably been, in most cases, derived from indigenous species. The urus or wild ox has been the parent of the common ox, and the wild boar of the domestic pig; the goat, and, in the extreme north, the reindeer, are also native to the European soil. The moufflon of Sardinia was perhaps the ancestor of at least some of our breeds of sheep.

The birds of Europe display a greater number and variety of species than its land animals. This is especially the case in regard to the family of aquatic birds—always most numerous in the higher latitudes. More than thirty species of the duck tribe alone belong to Northern Europe, some of them being common to the correspondent latitudes of Asia and the New World. The stork and the crane (both of migratory habits) belong to the maritime regions of western Europe; the pelican, the spoon-bill, and the scarlet flamingo, to the shores of the Mediterranean.

Europe has fewer species (as well as fewer individuals) of the reptile kind than either of the other divisions of the globe:—a happy exemption, which is due to its temperate climate. The only venomous serpents found in Europe are three species of viper, all of them confined to its southern shores: the common viper of middle and northern Europe is innocuous. Lizards are common in the south, as many as sixty-three species being enumerated.

The waters of Europe exhibit a rich variety of fish, a vast number of them useful as the food of man. Each of its inland seas has its own peculiar tribes, the Mediterranean

basin displaying the richest diversity. Among the inhabitants of the Mediterranean are several sharks, sword-fish, dolphins, and six species of tunny—the last-mentioned the largest of edible fish. The anchovy is peculiar to the Mediterranean. The seas that lie around the British Islands abound in the gregarious tribes of edible fish, as the cod, turbot, mackerel, herring, pilchard, and many others. The *stromming* of the Baltic is of like utility. The salmon frequents the estuaries and river-mouths throughout the coast line of western Europe to the northward of the Bay of Biscay, becoming more numerous as higher latitudes are reached.

The generally temperate climate of this continent secures it, for the most part, an exemption from the dense swarms of insect-life that belong to warmer latitudes. Yet between eight and nine thousand *species* are enumerated as native to the British Islands alone. The common honey-bee is distributed all over southern and central Europe, and is probably indigenous. The locust is only an occasional visitor to its shores, and belongs to the other side of the Mediterranean. The silk-worm was introduced from China towards the close of the fifth century of our era.

ASIA is rich in variety of animal life, and especially so as regards the class *mammalia*, all the orders of which but two (the marsupials and the edentata) are represented in its zoology. Among domesticated quadrupeds, the camel, ox, goat, and sheep, of the ruminants, with the horse, the ass, and the elephant, of the pachydermatous order, are natives of Asia. The camel, of which there are several species, all natives of this continent, ranges from the shores of the Indian Ocean and Red Sea as far north as Lake Baikal. The rein-deer and elk frequent the Siberian and Mongolian plains, migrating from the former locality southward with the approach of winter. Numerous varieties of the ox tribe (including the common ox, aurochs, buffalo, and yak) are reared by the Tartar nations who inhabit the upland plains of the interior. The antelope and deer tribe, of which there are a vast number of species, belong to the western and south-western regions of the continent. The plains of Turkestan, to the eastward of the Caspian, are perhaps the original country of the horse. The wild ass is indigenous to western Asia. The elephant is not found to the west of India, nor to the north of the Himalaya Mountains; it belongs only to the two Indian

peninsulas, with Ceylon, and some of the smaller islands of the East-Indian archipelago.

Among Asiatic carnivora are the lion, tiger, leopard, panther, and ounce, of the cat genus: the wolf, hyena, and jackal, of the dog tribe. Two species of bear are native to the Himalaya region (the snow-bear and the black-bear,) and the polar bear belongs to the arctic coasts of the continent. The lion of Asia is now restricted to the region which extends from the banks of the Euphrates and Tigris to the western coasts of the Indian peninsula, including the deserts of Mesopotamia, Persia, and Hindoostan. The tiger has a more extensive range, and inhabits all the middle and south-eastern divisions of the continent. The hyena, and also the jackal, belong to the western half of southern Asia; the wolf frequents the northern and western plains, and is found in a range of country extending from Siberia, through Turkestan, to the shores of the Mediterranean. The dog and the fox are common all over the continent, and present numerous varieties; in Kamschatka and some parts of Siberia, the former animal is used as a beast of burden, and is trained to draw the sledges over the vast plains of ice and snow.

Numerous fur-bearing animals occur in Siberia, including the bear, glutton, badger, wolf, fox, lynx, pole-cat, weasel, ermine, marten, otter, sable, squirrel, beaver, hare, and the rein-deer: many of these belong also to the northern regions of Europe. The quadrumanous animals are found in the south and south-east of the continent, and the islands of the East-Indian archipelago; the largest and most remarkable amongst them—the ourang-outang—is restricted to the Malayan peninsula and the islands of Borneo and Sumatra. The gibbons (or long-armed apes) belong exclusively to Asia, and abound in its south-eastern parts. Bats are more numerous in the islands of the Asiatic archipelago than on the continent.

Asia is less rich in variety of birds than in quadrupeds, but (with the exception of the turkey, which is a native of the New World, and of the guinea-fowl, which is African,) all our domestic poultry came originally from this division of the globe. Among its birds of prey, are eagles, vultures, falcons, owls, and hawks; but, although individually abundant, the species of these are not numerous. Song-birds are numerous in Western Asia, but are comparatively scarce in the eastern division of the continent, where, however, (especially among the islands of the Eastern archipelago and in China,) birds

of beautiful plumage abound. The peacock is a native of India, the golden pheasants belong to China, and the birds of paradise to New Guinea and the adjacent islands.

Reptiles are less numerous in Asia than in some other parts of the globe, but are sufficiently common in the south-eastern parts of the continent and the adjacent islands. The python (analogous to the boa-constrictor of the New World) lurks in the morasses and swamps of the East-Indian islands; the cobras, with several other kinds of venomous serpents, are found in the peninsulas of Eastern and Western India. Both sea and fresh-water snakes are numerous. Among insects, the locust is abundant in Western Asia, and commits the most frightful and dreadful ravages among the crops in Syria, Persia, and Arabia.

AFRICA is yet richer than Asia in regard to the animal kingdom. Of the total number of mammalia, more than a fourth occur in this division of the Old World, and fewer than a sixth of the number are common to Africa with either of the other continents. It is in the carnivorous, ruminating, pachydermatous, and quadrumanous orders that African zoology is more especially rich. Only one order, the marsupial, is unrepresented in it. Nor is the varied abundance of animal life in this region of the globe confined to species: the development of individual life within its vast and almost boundless solitudes, is yet more characteristic.

Among African beasts of prey are the lion, panther, leopard, wolf, fox, hyena, and jackal. Three varieties of the lion occur —that of Northern Africa, of the countries on the Senegal, and of the extreme south, towards the Orange river. There are two hyenas—one, the spotted hyena, a native of Southern Africa; the other, the striped hyena, indigenous to the more northerly parts of the continent, and extending its range from Abyssinia and Barbary into Western Asia. The wolf and the jackal belong to Northern Africa.

Of ruminating quadrupeds, there are no less than sixty species of the antelope kind, which is especially abundant in Southern Africa. The camelopard or giraffe is peculiar to this continent, and ranges from the banks of the Gariep to the southern borders of the Sahara, but is not found upon the western coasts. Several species of buffalo occur in a wild state, and are most abundant within the outlying districts of the Cape Colony. Sheep and goats abound in most parts of Africa.

but are probably not indigenous ; both in Barbary and near the Cape of Good Hope—at the opposite extremities of the continent—are found sheep with broad, fat tails, so large as sometimes to weigh from ten to thirty pounds. The camel of Africa is found all over its northern and central regions.

Of the pachydermata, or thick-skinned animals, the most characteristic are the elephant, rhinoceros, and hippopotamus. The elephant is found dispersed, in immense herds of from one to three hundred, all over the wooded regions of Central and Southern Africa, and the rhinoceros frequents principally the same localities. The ivory supplied by the tusks of the former is one of the most valuable native products of this quarter of the globe. The rhinoceros is valued chiefly for its hide, which is made into shields and harness.

The hippopotamus is found in the upper part of the Nile valley, and in all the lakes and rivers to the southward of the Great Desert—including the Senegal, the Gambia, the Congo, and the Gariep. This animal is peculiar to Africa ; its teeth consist of the finest ivory, for the sake of which it is hunted by the Cape Colonists, who likewise consume as food some portions of its flesh.

The wild boar is found in some parts of Africa : the zebra, dow, and quagga (all three peculiar to this continent), abound in its central and southern regions, particularly in the arid plains in the neighbourhood of the Orange river. Of the African quadrumana, monkeys, baboons, apes, and lemurs, abound in the forests throughout every part of the continent. The chimpanzee of the western coasts (from the neighbourhood of Sierra Leone to the 10th parallel of S. latitude), makes nearer approach to the human form than the orang-outang of south-eastern Asia, but is surpassed in this respect by the gorilla, one of the largest of the ape tribe, which inhabits the forests in the neighbourhood of the Gaboon river, (0° 30′ N. lat.)

Bats are numerous in Africa, and most of the species inhabiting this continent are peculiar to it. The rodentia (or gnawing animals) are also for the most part of peculiar species; among them are hares, rabbits, jerboas, squirrels, rats, and mice.

Among birds, the ostrich is confined to Africa, but ranges from its southern extremity to the northern borders of the Great Desert. Its feathers form a highly-valued article of traffic, and the bird is domesticated in many parts of Africa for the sake of procuring these free from injury. The vulture

(of which two species occur—one in Northern Africa, and the other in the neighbourhood of the Cape) serves here, as elsewhere, to preserve the air from impurity, by feeding on the carcases of animals, and divides with the hyena the office of scavenger. The owl, falcon, and eagle, are also enumerated amongst the African birds of prey. Of gallinaceous birds Africa possesses only the Guinea fowl; but the domestic poultry are numerously reared, though not indigenous. The woods of tropical Africa abound in numberless varieties of parrots and paroquets, besides many other birds of bright and gaudy plumage,—as the beautiful sun-birds (which inhabit the western coasts, and are scarcely larger than the humming birds of America), together with the golden-coloured orioles, crested hoopoes, bee-eaters, and others. The honey-suckers, which abound in the neighbourhood of the Cape of Good Hope, feed entirely upon the nectar or saccharine juice of the proteas and similar plants. The sun-birds also occur in Southern Africa, and rival those of India and the Gambia in the brilliancy of their colours.

Lizards, serpents, and reptiles of every description, abound in various parts of the African continent, though its general aridity, throughout extensive regions, is less favourable to the development of reptile life than in the case of correspondent latitudes elsewhere. The crocodile inhabits all the large rivers of tropical Africa, and is abundant in the lower portion of the Nile. The huge python, sometimes twenty-two feet in length (though inferior in size to the boa of the New World), is found in the swamps and morasses of the western coast, and some species of the cobra (or hooded snake) occur,—chiefly in Southern Africa and on the shores of Guinea. Insects abound, both in species and as individuals; among them is the locust, which at intervals ravages all the northern parts of the continent. But the termites, or white ants, of Western Africa are the most celebrated members of the insect-family, and effect the most extraordinary destruction of furniture, books, clothes, food, and everything that comes in their way. They build for themselves pyramidal or conical nests, firmly cemented together, and divided into several apartments,—so large that at first sight they appear in the distance like the villages of the natives. Both the bee and wasp are numerously distributed, but the bee has not been domesticated by any of the native people of this continent; it is, however, reared by the Arabs in Northern Africa.

AMERICA.—The New World exhibits, through its vast prolongation in the direction of latitude, a development of animal life which is almost infinitely varied, and which differs in many essential regards from that belonging to either of the continents of the eastern hemisphere. Each of the nine orders of mammalia is represented within its limits, but many of the most attractive and valuable members of the animal life of Asia and Africa are nevertheless wanting. America has neither the elephant nor the camel; and neither the horse, the ox, the sheep, nor the hog, are indigenous to it.

The carnivora of the New World are inferior in size, strength, and ferocity, to those of Asia and Africa. In place of the lion, America has only the puma—a smaller and less powerful creature. The tiger of Southern Asia is represented by the jaguar, a somewhat smaller animal, but the most powerful of the American carnivora. In North America, however, the numerous bears are distinguished by their size and power, particularly the grizzly bear of the countries which border upon the Rocky Mountains. The great white bear of the polar regions is common to the high latitudes of either hemisphere. North America, which is more strictly continental in extent than the southern half of the New World, possesses, indeed, other types of animal life which rival those of the Eastern hemisphere. Among these are the majestic bison, or American buffalo (vast herds of which inhabit the immense prairies to the eastward of the Rocky Mountains),—together with the elk or moose-deer, occupying a place similar to the rein-deer of Northern Europe and Asia. Several varieties of the deer-kind occur in the northern half of the continent, together with the musk-ox, the big-horned sheep, and the Rocky Mountain goat, which are peculiar to this region.

The tapir and the peccary (an animal of the hog kind) range all over the plains of South America, and the former is also found on the coast of Central America. The puma (or cougar) occurs on the Mexican Isthmus, and even as far northward as the 45th parallel, though found most numerously in the southern half of the continent, where its range extends to within a few degrees of the Strait of Magellan. The jaguar is found in the coast regions of the Mexican Isthmus, as well as the forests of Brazil and the adjoining regions of South America. The lynx and the wolf belong to the colder tracts of North America.

The opossums are numerous in South America, and one

species is met with in the United States (Virginia); this family (marsupialia) is altogether absent from the eastern continent, but is fully developed in the Australian division of the globe. The beaver abounds in the colder latitudes of North America, together with a vast number of other fur-bearing animals; as racoons, martens, squirrels, sea-otters, minks, musk-rats, ermines, foxes, wolverines, and hares.

The llama tribe (comprehending, besides the llama, the alpaca, vicuna, and others) is peculiar to South America. Its members are found throughout the prolonged cordilleras of the western side of that continent, from Chili to New Granada, dwelling always at considerable heights above the level of the sea. The llama belongs to the same order (ruminantia) as the camel of the Old World, and supplies some of the uses of that animal as a beast of burthen. Prior to the Spanish conquest, the llama was, indeed, the only beast of burthen which the natives of South America possessed. The tapir of the same continent (an animal about the size of a small cow, and readily distinguished by the downward bend of its snout) belongs to the order of pachyderms. Two species of tapir, both of them peculiar to that region, inhabit South America: a third species is native to the island of Sumatra, and the adjacent Malay peninsula, in south-eastern Asia.

The sloth, ant-eater, and armadillo (all belonging to the order of edentata, or toothless animals) are natives of South America. Monkeys are exceedingly numerous all over that continent, especially in the forests of Brazil. These, however, are different in species from the monkeys of the eastern hemisphere; they are of smaller size, and all possess tails, mostly prehensile. None of the apes of the New World make the same approach to the human form which is found either in the chimpanzee and gorilla of western Africa, or the orang of south-eastern Asia. Towards the close of day the howling monkeys of Brazil make the woods resound with the most frightful cries; but they are neither of large size nor of formidable powers. The chinchilla, a small animal (belonging to the order of rodents) which yields a delicate and beautiful fur, is confined to the southern portions of the Andes. Bats are very numerous in South America,—more so than in any other part of the world: among them is the large vampire-bat, which frequently sucks the blood of horses and mules during the night. All of them differ in species from the bats of the eastern continent.

The ornithology of tropical America exceeds in splendour that of any other region of the globe. Among the principal birds of prey are several species of eagle—including the large white-headed eagle of the United States, with vultures, hawks, kites, and owls. South America, however, possesses the largest of the vulture-tribe—the gigantic condor of the Andes, which is confined to the higher peaks of those mountains, bordering on the limits of the snowy region. This is one of the most powerful and rapacious of birds, and commits numerous ravages amongst the cattle, deer, and other animals. The American ostrich, or emu, which dwells in the pampas of that region, is also distinguished by its size.

The humming-birds are peculiar to the western continent, and in the tropical regions of America various birds of the most glittering plumage, together with numberless fire-flies, lend an almost magical charm to the aspect of nature. The range of the humming-birds extends over the whole continent to the southward of the 42d parallel (north lat.,) and stretches upon the western side of North America as high as the parallel of 60°—an evidence of the superior warmth which distinguishes that side of the American continent.

Both reptiles and insects are abundant in the New World, which, owing to its excessive moisture and dense vegetation, is peculiarly suited to the development of these departments of the natural kingdom. Venomous serpents are more numerous in tropical America than in any other part of the globe. The rattle-snake occurs in both divisions of the continent, within the parallels of 44° to the northward, and of 30° to the south, of the equator; the huge boa-constrictor, the largest of the serpent tribe, and the terror even of the natives, dwells in the marshes and swamps of South America. Huge caymans, iguanas, and other lizards, with numberless alligators and water-snakes, abound in the rivers and temporary lagoons of the same region.

AUSTRALIA possesses a zoology which is more distinctive than that of any other part of the world. Its native insects, reptiles, birds, and land animals, are all strikingly different from those of other regions. The difference is greatest (or, at any rate, most obvious to ordinary observation) in the case of its land animals. Two-thirds of the Australian mammalia belong to the marsupial order, and the kangaroo, the largest member of that family, surpasses in size any other of its

indigenous quadrupeds. The quadrumanous, pachydermatous, and ruminating orders are altogether unrepresented, nor are there any of the larger carnivora—the native dog (already verging on extinction) being the chief amongst them. The changes in zoological distribution which have been consequent on colonial enterprise in this region have been already adverted to.* In the present day, large numbers of the Australian population are employed in rearing the domestic cattle of Europe.

Australia forms in all regards a distinct zoological province, and its insulated position has tended, in greater measure than is the case with any other part of the world, to confine the distinguishing features of its fauna within its own proper limits. The kangaroo family includes numerous distinct species, from the full-sized kangaroo down to the kangaroo-rat. But not a single one of the tribe is found beyond the limits of Australia and the neighbouring island of Tasmania. The opossums, which belong to the same *order,* are only found elsewhere in the New World. The most remarkable, however, amongst the members of the Australian animal world is that popularly known as the duck-bill (*platypus,* or *ornithorynchus,*) which constitutes a puzzle to the naturalist. This is a semi-aquatic creature, about twelve or thirteen inches in length, with the body of an otter, a bill like that of the duck, and which lays eggs. As one of the tribe of mammalia (to which, by its habits, it belongs), the platypus must be classed under the head of the edentata: while, on the other hand, as being oviparous, it may be regarded as belonging to a totally distinct division of the animal world.† The platypus frequents the margins of creeks and pools, but remains mostly in the water, and is only approached with difficulty, on account of its extreme shyness. It has a coating of soft fur, variously shaded from black to silver-grey.

Australia is distinguished by an extreme paucity of animal life (in so far as land-animals are concerned), in even a higher degree than by the limited number of its native species. This is readily explained by the generally arid character of its

* Page 218.

† When the platypus was first brought to England, a learned naturalist to whom is was shown doubted the real existence of a creature so anomalous, regarding the specimen as the result of an intention to impose upon his credulity. This was, of course, a stuffed specimen. It is with difficulty that the platypus can be taken alive: the natives, however, sometimes succeed in trapping them.

interior, the scantiness of the native vegetation, and the consequent difficulty of finding food. The traveller may frequently pass over many hundred miles of country without meeting with a single quadruped, and almost without finding the traces of a single land-animal. Its characteristics in the latter regard are undergoing, however, a rapid change: the horse and the ox, introduced by the European settlers, have in some cases reverted to a state of nature, and a herd of wild cattle is now not unfrequently met with, beyond the ordinary limits of the settlers' range.

The ornithology of Australia is richer and more varied than other branches of its animal life. Its chief distinction consists in the vast proportion of *suctorial* birds—that is, such birds as derive their principal support from sucking the nectar of flowers. This peculiar organisation, restricted, in Africa, India, and America, to the smallest birds in creation, is here developed very generally, and belongs to species that are as large as an English thrush. The *melliphagidæ*, or honeysuckers, take the place of the humming-birds of the New World: like all the family to which they belong, they have the tongue terminating in a brush-like bundle of very slender filaments, with which they suck the nectar of flowers.

Among the native Australian birds are a vast number of the parrot tribe, comprehending paraqueets, cockatoos, and others, many of them distinguished by the most beautiful plumage. Of birds of prey, eagles, falcons, and hawks are numerous, as well as several owls. The largest among the feathered tribes of Australia is the emu, or cassowary,—a bird of the ostrich kind, though of rather inferior size to the African ostrich. It is found chiefly in the southern portions of the continent, but is yearly becoming scarcer under the advance of the settlers.*

The scattered islands of the Pacific, which, under the name of Polynesia, constitute, in modern geography, one of the divisions of the globe, can hardly be regarded as a distinct zoological region; so obviously has their animal life been derived from other lands. When first visited by European navigators, little more than a century since, the largest quadruped found

* The emu and cassowary, though in common language referred to as identical, are specifically distinct. Of the cassowary, properly so called, three distinct species are now known—one of them an inhabitant of the Australian mainland, in the neighbourhood of Cape York, a second native to New Guinea, and a third inhabiting the island of New Britain.

in the Polynesian groups was the hog, which had probably accompanied the tribes of mankind by whom they were first peopled. The only other land-animals were the dog, mouse, and lizard, with a few rats. There were neither reptiles nor insects; musquitoes, fleas, centipedes, and scorpions, have since been introduced.

The native fauna of New Zealand is hardly less scanty than that of the smaller groups of the Pacific. The largest animal found there by the first European settlers was the pig, which is probably not indigenous, though it has reverted to a state of nature. Dogs are the only beasts of prey: a few rats and mice complete the list of its mammalia. There are no marsupials, though New Zealand is nearer by many thousand miles to Australia than to any of the other continents. The feathered tribes are equally few in number, but they include at least one species—now fast approaching extinction—the antervx (a wingless bird), which has no representative elsewhere.

XV.

GEOGRAPHICAL DISTRIBUTION OF MAN.

It is estimated that the Earth is inhabited, at the present time, by from eleven to twelve hundred millions of human beings, who are distributed over its surface in the manner shown in the following table :—

	Area in British square miles.	Population.	Population to square mile.
Europe, . . .	3,700,000	275,000,000	74
Asia, ...	17,000,000	700,000,000	41
Africa, ...	12,000,000	100,000,000	8
North America (including West Indies,) .	8,600,000	45,000,000	5
South America, . .	7,000,000	20,000,000	2·8
Australia, . . .	3,000,000	1,500,000	·5
Polynesia, . . .	120,000	500,000	
	51,420,000	1,142,000,000	

Europe is therefore, relatively to its size, by much the most populous division of the globe, though Asia contains the highest absolute number of inhabitants—amounting, indeed, to little less than two-thirds of the entire human race. The New World is very much less populated by man than the older-known portions of the globe, though its capabilities for the support of the human race fully equal those of any of the continents of the eastern hemisphere. Australia, and the scattered islands of the Pacific Ocean, are the least populous portions of the earth, the total present number of their inhabitants amounting to a mere fraction of the entire number.*

* The figures given in the above table represent no more than an approximate estimate. It is only in the case of Europe that we possess the means

The numerical distribution of mankind undergoes great change in the present day, when emigration from over-populated lands to distant parts of the globe is conducted on so extensive a scale. But this affects the distribution of *race* in much higher measure than it does the merely numerical distribution of man. The fast-increasing numbers of the settlers in the fertile plains and river-valleys of the New World, descendants of European colonists, perhaps hardly more than replaces, numerically, the native races who occupied the same regions, prior to the first visit of the white man to their shores. It is the tendency, everywhere, of the native races to decay before the white settler. Wars, famine, epidemic diseases, and various social causes, again, tend to keep down the total number of the human family—at any rate, to check the more rapid numerical growth which it would otherwise exhibit.

The generally-recognised ethnological division of mankind, with reference to race, is into three leading families—the *Caucasian*, *Mongolian*, and *Negro*. Two other families—the *Malay* and the *American*—are commonly added to these, making five in the total. The first-named division is that suggested by the illustrious French naturalist, Cuvier. The fivefold division is due to the German philosopher, Blumenbach. In the scheme of the former, the Malay and American are regarded as sub-varieties—the one of the Caucasian, and the other of the Mongolian family. Other writers, again, enumerate a much greater number of varieties of mankind, each of which possesses characters sufficiently distinct to entitle it to be regarded as a separate family.

In using the word *race*, as applied to different families of man, the division must be understood as implying "variety" only—not species. There is no *specific* difference in the various members of the human family—no difference, that is, which implies anything in contradiction to the assumption that all mankind have had a common origin, springing from a single pair. The human family differs in this regard from

of making such calculations with any approach to accuracy. The amount of the population of China alone has been stated with wide variations—the estimates ranging between two hundred millions and more than double that number. We adopt above the higher number, which appears to be confirmed by the general testimony of observers. The number of inhabitants within the African continent (and especially within those portions of it populated by the negro race) is scarcely more than a guess: the figures given above are probably rather below than in excess of the truth.

all the lower members of the animal kingdom. The order "bimana" (i.e., *two-handed*), to which, in scientific classification, man is referred, comprises only a single genus, and a single species.

The characteristic points of difference between the great families of mankind above referred to are—the colour of the skin, eyes, and hair (with the nature of the latter, whether curled, lank, woolly, or frizzled); with the shape of the skull. All other physical differences, as regards stature, form of limbs, and general outline of body, seem capable of ready explanation, by reference to opposite conditions of climate, food, and habits of social life. But between the Caucasian and the Negro, or the latter and the Mongol, there is a broad and strongly-marked difference, and one that extends over the whole historic period.

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1. CAUCASIAN. The distinguishing attributes of the Caucasian race, physically considered, are—the oval form of the skull, with the generally symmetrical shape of the entire head and frame of body. The face is of oval form, the features moderately prominent, the forehead arched, the cheek-bones only slightly projecting, the mouth small, the chin full and round; with the skin generally of light colour (varying, however, from white to a deep brown, or swarthy, hue), the eyes and hair of various hue, and the latter often curling. The facial angle * is greater in the case of the Caucasian than in either of the other varieties of mankind.

The epithet *Caucasian*, applied to this branch of the human family, is derived from the high mountain-range which stretches between the Black and Caspian Seas, and is justified by the fact that the finest specimens of man—physically considered—have in all ages been found in proximity to that region. The perfect forms, and external beauty, of the Circassian and Georgian people—male and female alike—are well known. The finest types of the white race (mere physical beauty alone being considered) are to be found within

* The facial angle is formed by the meeting of two lines drawn on the profile of the skull—one of them a line touching the projecting part of the forehead and the gum of the upper jaw, the other connecting the base of the nose and the opening of the ear. The angle formed by the meeting of these lines sometimes amounts in the Caucasian variety of man to 80 degrees and upwards: in the other varieties it seldom exceeds 70 degrees, and in the instance of some degraded races is considerably less.

the elevated region of the Caucasian isthmus; and it has even been sought to show that the human form degenerates in proportion as its distance thence, in whatsoever direction, is increased.* To the westward of the Caucasus (whatever may be case in other directions), the grace which attends on moral and intellectual dignity is, however, added to that of merely personal beauty.

Considered in reference to colour, the Caucasian is the *white* variety of the human family; but the latter epithet must be considered as applicable only in a general sense, for numerous shades of colour intervene between the swarthy complexions of the sub-tropical regions that border on the Mediterranean, and the fair skins of the people of northern and north-western Europe. These differences are doubtless in some measure dependent on climate. Yet there must be a well-grounded difference due to other causes, since families of whites dwell during several successive generations within the tropics without acquiring the hue of the negro, or settle within the western continent without gaining any external resemblance to the copper-coloured native of the New World.

The geographical distribution of the Caucasian family in the present day is nearly co-extensive with the land-area of the globe; but this family of nations is most numerously developed within the temperate latitudes of the northern hemisphere. Western Asia, the European continent (with the exception of a portion in the extreme north), and the northern belt of Africa, are the proper home of the Caucasian tribes. Thence they have colonised nearly every part of the New World, as well as Southern Africa and the more distant regions of Australia and New Zealand, at the opposite side of the globe. Nine-tenths of the population of Europe belong to the Caucasian family of man, the small minority who constitute the exception consisting of the Turks, the Magyars, the Finns, the Laplanders, and the Samoiedes. In Asia, the Caucasian natives form but a minority of its vast population; they include, however, the natives of the Arabian or Semitic stock, the Persians, the Afghauns, and perhaps also (such, at least, is the generally-received theory) the Hindoos—that is, all the people dwelling to the south of the Himalaya and to the west of the Bay of Bengal. In Africa, the proportion of Caucasians to its population is probably small, though they are spread over the whole of Northern

* Guyot: *Earth and Man.*

Africa, from the Mediterranean to the southern border of the Desert, and the furthest limit of Abyssinia.

In America, the Caucasian family—settling in that part of the world as colonists only within the last three centuries and a half—is fast supplanting the indigenous races, and comprehends two-thirds of the total number of its inhabitants in the present day. Within the temperate latitudes of North America, that is, within the valleys of the Mississippi and St Lawrence, with the Atlantic sea-board from the Gulf of St Lawrence southward, the white race is most numerous. Five-sixths of the present population of North America belong, either in whole or in part, to the Caucasian stock.

In the case of Australia, the diminution in the numbers of the native race has been even more rapid than in the case of the Western continent. The white race, whose date of settlement on the Australian shores is as yet under three-quarters of a century, now vastly outnumbers the indigenous tribes. In the island of Tasmania, the latter have indeed become all but extinct. Even in New Zealand, which was peopled by an athletic tribe of savages when Captain Cook visited it less than a century since, the colonial population, planted on its shores within the last five and twenty years, already outnumbers the native tribes, which moreover undergo gradual diminution in numerical amount.

2. The MONGOLIAN variety of man is distinguished by a greater approach to squareness in the shape of the skull (viewed from above), with greater prominence in the cheek-bones—so that lines prolonged from the sides of the face upwards meet in a point, giving the entire framework of the head a pyramidal shape. The forehead is comparatively low and slanting; the face and nose broad and flat; the eyes deeply sunk, with the inner corner slanting towards the nose; the complexion of an olive or yellowish-brown colour, the hair lank and black, the beard scanty, the stature below that of Europeans, and the frame generally broad, square, and robust, with high shoulders, and the neck thick and strong. These attributes are much less strongly marked in the case of some nations of Mongol parentage than in others, and in the instances of the Magyars, Turks, and Finns—long settled amongst the Caucasian family—have in great measure disappeared.

The name of Mongolian, applied to this branch of the human family, is derived from the nomade races who people the up-

land plains of Central Asia. It comprehends, besides the Mongols proper, the vast population of China (above a third of the entire human family), together with the Burmese, Siamese, and other inhabitants of the south-eastern peninsula of Asia, and the native tribes of the Siberian lowland. The Turks and the Magyars, in south-eastern and central Europe, the Finns, Samoiedes, and Laplanders, in the extreme north of the same continent, and the Esquimaux, in the correspondent latitudes of the New World, belong to the same stock. In all, probably three-fifths of the population of Asia, and more than a half of the population of the globe, are comprehended within this division of mankind.

In point of colour, the Mongolian is known as the *yellow* variety of mankind.

3. The NEGRO, or *black* variety of mankind, is distinguished in general by the elongated form of the skull, combined with a low facial angle. The eyes, as well as the skin, are black; the nose broad, flat, and thick; the cheek-bones prominent; the lips thick; the jaws (especially the lower one) narrow and projecting; the hair woolly; the palms of the hands and the soles of the feet flat; and the forms of the arms and lower extremities generally clumsy and ungraceful. These attributes, however, are very much modified in the case of some members of the Negro race, and they belong in very various degree to the different Negro nations who inhabit the African continent. The black skin, woolly hair, thick lips, and elongated skull, are the most striking features of the Negro race.

Africa, to the south of the desert, is the proper home of the Negro race. Tribes of true Negro stock occupy by far the larger portion of that great continent, to the southward of the Senegal, the Niger, the basin of Lake Chad, and the highlands of Abyssinia. The Arabs, however, have penetrated Central Africa within the basins of the Niger and Lake Chad, and have been settled for upwards of five centuries upon the coasts of Eastern Africa.

If we accept the broad generalisation which divides the family of man into three (or even five) varieties, the Hottentot and Caffre families, who inhabit the extreme south of the African continent, must be classed as sub-varieties of the Negro stock. But between the Hottentot and Negro types there is a broad and well-marked distinction, and not less so between the Hottentot and the Caffre families. The colour

of the Hottentot is a dark and yellowish brown; the hair short and frizzled, and distributed over the head in tufts; the stature short. The Caffres are well-made, and (comparatively to their neighbours of Hottentot race) of muscular frame—their limbs of rounded form, their skin of deep brown colour, their hair short, black, and curly, but less woolly than that of the Negro.

The Negro race, through the iniquities of the slave-trade, has been transplanted from Africa to the other side of the Atlantic, and now forms a considerable item in the population of the New World. In North America, the people of pure Negro blood amount, however, to hardly more than a twelfth part of the total population: in South America the proportion is perhaps rather more considerable.

4. The MALAY, or brown family of nations, is distinguished, besides the colour of the skin, by lank, coarse, and black hair; with flat faces, and obliquely set eyes. Their stature is below the average height either of the Caucasian or the Mongol, and the figure generally equal and robust. If the nations of the Malay family are to be referred to one of the three greater divisions, they must be regarded as a sub-variety either of the Mongol or the Negro stock. Proximity of geographical position, with other circumstances, would lead us to prefer the former. The Papuans, however, who inhabit New Guinea and the adjacent islands to the eastward, exhibit many of the characteristics of the Negro type, and the native race of Australia is of the Papuan or Austral-negro family. There is, in truth, throughout the Australian and Polynesian division of the globe a well-marked distinction between the brown and the black races. The former, who belong to the true Malay family, comprehend, with the Malays proper (that is, the bulk of the inhabitants of the Malay peninsula and the adjacent islands), the people of Madagascar; also the New Zealanders, and the inhabitants of most of the smaller Polynesian archipelagoes, from the Sandwich Islands on the north to the Society, Navigators, and Friendly groups in the south. The Austral-negro or Papuan division, on the other hand, includes the native tribes of the Australian continent and the adjacent island of Tasmania (the latter reduced to *fourteen* individuals), with the inhabitants of New Guinea, the Louisiade archipelago, New Britain, the Solomon Islands, the New Hebrides, New Caledonia, and the Feejee Islands.

5. The AMERICAN, or red variety of mankind, has its home in the two great continents which are together known as the New World. Its distinguishing attributes are—a reddish or copper-coloured skin, with long, coarse, black hair (which is never crisped, like that of the negro, or curled, as that of the white often is), and scanty beard. The cheek-bones are prominent, but more arched and rounded than those of the Mongol, without being so angular, or projecting at the sides; the orbit generally deep, and the outer angle slightly elevated. In point of temperament, the Indian (as the native inhabitant of the American wilderness is termed) is cold and phlegmatic to an unusual degree, and he manifests an extraordinary insensibility to bodily pain. His bodily senses—of sight, hearing, and smell—are remarkably acute. These, as well as many other attributes of the Indian race, have doubtless resulted from the conditions of the hunter's life, pursued through many generations.

The above characteristics, however, are exhibited in widely-different measure in the case of the numerous native tribes and nations that are found through the whole wide extent of the American continent, though all of them (with the exception of the Esquimaux) are classed under the common term Indian. The native races of South America are generally further removed than those of North America from the higher type of the American family, and they become progressively more degraded towards its furthest extremity. Some of the Indian tribes who dwell in the Brazilian forest exhibit a degree of personal ugliness, and a degradation of condition in general, which contrasts strikingly with that of the higher classes of North American Indians, and the native savages of Tierra del Fuego are among the most misshapen and degraded of the human race. In these and some other cases, the distortion of feature, and even that observable in the shape of the head, is produced by artificial means, applied in infancy.

The Indian family of nations makes perhaps nearer approach to the Mongol than to either of the other two great divisions of mankind, and must be regarded as a sub-variety of that family, if three great varieties only be allowed. The Esquimaux, who inhabit the extreme northern shores of the New World, are uniformly regarded as of Mongol origin.

THE END.

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